THE

MINERAL INDUSTRY

1903

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During

1903

FOUNDED BY THE LATE
RICHARD P. ROTHWELL

PREPARED BY
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CONTENTS FOR VOLUME XII.

(Articles marked with an asterisk are illustrated.)

PAGE

ASBESTOS.

ASPHALTUM.

BARYTES.

BAUXITE.

BROMINE.

CARBORUNDUM.

CEMENT.

CHROMIUM AND CHROME ORE.

INTRODUCTION.

The total value at the place of production of the mineral and metal output from both domestic and foreign ores and bullion of the United States in 1903 was $1,670,317,905, as compared with $1,508,153,646 in 1902, a gain of $162,164,259 for the year.

Of these vast sums, which exceed all previous records, ores and minerals, including secondary products, contributed $1,053,190,276 in 1903, as compared with $882,193,724 in 1902, and metals of foreign and domestic origin, $617,127,629 in 1903, as compared with $625,959,922 in 1902. In these totals are included certain duplications, such as those of manganese and iron ore used in making ferromanganese and pig iron; bauxite used in making aluminum and alum; coal used in making coke; lead used in making white lead, red lead and litharge, and certain other duplications, the whole amounting to $113,042,780 in 1903 and $115,644,546 in 1902. Deducting these amounts and also the values of the crude foreign ores or metals smelted or refined here, the net value of the mineral industry of the United States was $1,474,275,125 in 1903 and $1,315,240,888 in 1902.

In the preparation of the statistics for this volume, the figures previously reported for 1902 have been revised in the light of more minute investigation in accordance with our practice; wherefore it is important to use always the figures in the latest volume of THE MINERAL INDUSTRY. There are no statistical reports of this nature which are absolutely correct, owing to the practical impossibility of obtaining accurate reports from all producers in extensive and subdivided industries, the absence of records on the part of many producers which prevents them from making returns, the unwillingness of a few to give figures, and confusion as to the stage in which many products are reported.

For many of the statistics relating to the mineral production of the United States in 1902 and 1903, we are indebted to the Department of Mineral Resources of the United States Geological Survey, and for the production of gold and silver in the United States during these years to Mr. George E. Roberts, Director of the Mint. Acknowledgment is due also to various State geological surveys and statistical bureaus for information incorporated in the volume. We have generally credited such information to the proper sources, but this acknowledgment may stand for any unintentional oversights.

PRODUCTION OF ORES AND MINERALS IN THE UNITED STATES.

Number.	Products.	Measures.	1902. Quantity.	1902. Value.	1903. Quantity.	1903. Value.
1	Asbestos	Sh. T.	1,010	$12,400	874	$14,160
2	Asphaltum	Sh. T.	35,132	455,854	53,552	678.756
3	Asphaltic limestone	Sh. T.	1,859	7,782	2,520	8,800
4	Bituminous sandstone	Sh. T.	57,837	157,093	38,633	118,001
5	Barytes	Sh. T.	58,149	186,713	50,397	152,150
6	Bauxite	L. T.	29,222	128,206	48,087	171.306
7	Bismuth ore	Sh. T.	37	2,960	*Nil.*	....
8	Bromine	Lb.	513,913	128,472	597,000	170,140
9	Calcium borate	Sh. T.	20,004	2,538,614	*a* 34,430	661,405
10	Carborundum	Lb.	3,741,500	374,150	4,760,000	476,000
11	Cement Nat. Hyd.	Bbl. *g*.	8,044,305	4,076,630	7,030,271	3,675,520
12	Cement, portland	Bbl. *h*.	17,230,644	20,864,078	22,342,973	27,713,319
13	Cement, slag	Bbl. *h*.	478,555	425,672	525,896	542,502
14	Chrome ore	L. T.	315	4,725	150	2,250
15	Clay products	....	....	122,169,531	....	130,962,648
16	Coal, anthracite	Sh. T.	41,451,267	83,002,229	75,288,206	158,100,232
17	Coal, bituminous	Sh. T.	*l* 258,371,987	285,574,339	*l* 277,076,986	327,075,530
18	Cobalt oxide	Lb.	20,870	45,450	120,000	228,000
19	Coke	Sh. T.	23,106,959	52,116,741	25,262,360	66,459,623
20	Copper sulphate *c*	Lb.	48,763,538	2,028,563	43,124,454	1,811,227
21	Copperas	Sh. T.	19,784	118,474	20,240	121,440
22	Crushed steel	Sh. T.	368	51,450	378	52.850
23	Emery	Sh. T.	4,251	104,605	2,542	64,102
24	Feldspar	L. T.	45,287	250,424	41,891	256,733
25	Fluorspar	Sh. T.	48,018	271,832	42,523	213,617
26	Fuller's earth	Sh. T.	14,100	109,980	11,280	77,570
27	Garnet	Sh. T.	3,722	122,826	4,413	146,955
28	Graphite, artificial	Lb.	2,358,828	110,700	2,620,000	178,670
29	Graphite, amorphous	Sh. T.	4,739	55,964	16,591	71,384
30	Graphite, crystalline	Lb.	4,176,824	153,147	4,525,700	164,247
31	Gypsum	Sh. T.	816,478	2,089,341	1,041,704	3,792,943
32	Iron ore	L. T.	34,636,121	64,796,546	32,471,550	55,201,635
33	Lead, white	Sh. T.	114,658	11,978,172	112,700	12,228,024
34	Lead, red	Sh. T.	11,669	1,262,712	12,300	1,385,900
35	Lead, orange mineral	Sh. T.	867	138,349	1,000	168,000
36	Litharge	Sh. T.	12,755	1,299,443	12,400	1,326,800
37	Magnesite	Sh. T.	3,466	21,362	3,744	10,595
38	Manganese ore *d*	L. T.	973,937	2,127,783	660,582	1,670,349
39	Mica, sheet	Lb.	373,266	83,843	90,100	17,128
40	Mica, scrap	Sh. T.	1,028	13,081	1,693	41,990
41	Mineral wool	Sh. T.	10,843	105,814	(*b*)	....
42	Molybdenum ore	Sh. T.	15	750	(*b*)	....
43	Monazite	Lb.	802,000	64,160	862,000	64,630
44	Natural gas	....	....	30,867,668	....	35,815,360
45	Ocher *j*	Sh. T.	73,049	944,332	62,122	646,222
46	Petroleum, crude	Bbl. *i*	89,184,497	71,536,425	100,496,400	94,330,000
47	Phosphate rock	L. T.	1,600,813	5,041,362	1,570,228	4,993,912
48	Precious stones	....	....	328,450	....	321.400
49	Pyrite	L. T.	228,198	971,796	199,387	787,759
50	Salt *k*	Bbbl.	23,849,221	5,668,636	18,968,089	5,286,988
51	Silica, quartz	Sh. T.	36,365	144,209	55,233	156,9473
52	Diatom. earth	Sh. T.	5,665	53,244	9,219	76,27
53	Grindstones	....	....	667,431	....	721,446
54	Millstones	....	....	59,808	....	52,552
55	Pumice	Sh. T.	700	2,750	885	2,665
56	Sand	Sh. T.	1,847,901	1,423,614	2,110,660	1,831,210
57	Whetstones	....	....	32,980	....	69,909
58	Slate, roofing *f*	Squares.	1,435,168	4,950,428	1,378,194	5,400,078
59	Slate, manufactures	....	....	745,623	....	856,807
60	Slate pigment	Sh. T.	4,071	39,401	(*b*)	....
61	Soda, natural	Sh. T.	16,000	208,000	(*b*)	....
62	Stone, building	....	....	64,559,099	....	67,960,468
63	Stone, limestone flux	L. T.	12,139,248	5,271,252	12029,719	5,423,732
64	Sulphur	L. T.	8,336	*n* 169,746	, 39,310	*n* 789,738
65	Talc, common	Sh. T.	26,854	525,157	26,671	418,460
66	Talc, fibrous	Sh. T.	71,100	615,350	32,230	225,600
67	Tungsten ore	L. T.	221	38,600	(*b*)	....
68	Zinc ore exported	Sh. T.	55,733	1,449,104	39,418	987,000
69	Zinc white, *m*	Sh. T.	52,730	4,023,299	54,034	5,005,394
70	Zinc-lead	Sh. T.	4,000	225,000	4,500	253,125
	Est. production unspecified	....	....	22,000,000	....	24,500,000
	Total	....	....	$882,193,724	....	$1,053,190,276

PRODUCTION OF METALS IN THE UNITED STATES.

Number.	Products.	Measures.	1902.		1903.	
			Quantity.	Value.	Quantity.	Value.
71	Aluminum	Lb.	7,300,000	$2,284,590	7,500,000	$2,325,700
72	Antimony	Lb.	6,464,000	495,789	6,174,000	389,579
73	Copper	Lb.	645,887,447	p 75,161,922	689,045,796	p 90,726,660
74	Ferromanganese q	L. T.	212,981	13,852,199	192,661	9,488,554
75	Ferromolybdenum	Lb.	16,000	19,600	(b)	....
76	Ferrotungsten	Lb.	14,000	4,060	(b)	....
77	Gold	Troy oz.	3,870,000	80,000,000	3,560,000	73,591,700
78	Iron, pig	L. T.	17,608,326	308,145,705	17,816,591	285,965,456
79	Iridium	Oz.	20	400	....	....
80	Lead	Sh. T.	280,524	22,829,043	276,694	23,447,050
81	Molybdenum	Lb.	35,000	62,125	(b)	....
82	Nickel	Lb.	5,748	2,587	114,200	45,900
83	Platinum	Troy oz.	94	1,814	110	2,080
84	Quicksilver	Flasks o	34,804	1,515,714	37,123	1,564,734
85	Silver	Troy oz.	55,500,000	28,948,800	54,300,000	29,322,000
86	Tungsten	Lb.	82,000	50,020	(b)	....
87	Zinc	Sh. T.	158,237	15,317,342	158,502	17,118,216
	Total	....	....	$548,691,710	....	(r)534,127,629
	Total ores and minerals	....	....	882,193,724	....	1,053,190,276
	Grand total	....	....	1,430,885,434	....	1,587,317,905

In using the statistics in the foregoing tables, reference should be also made to the detailed tables under the respective captions further on in this volume, where many explanatory notes as to the statistics will be found. The following notes refer to the two preceding tables: (a) Crude material; the statistics for 1902 represent mostly refined borax. (b) Not enumerated. (c) Includes copper sulphate made from metallic copper. (d) Includes manganiferous iron ore. (e) Estimated. (f) Quantity expressed in squares, i.e., 100 sq. ft. lapped and laid. (g) Barrels of 300 lb. (h) Barrels of 400 lb. or 380 lb. net. (i) Barrels of 42 gallons. (j) Includes ocher, umber, sienna and oxide of iron. (k) Includes salt used in alkali manufacture; the barrel of salt weighs 280 lb. (l) Includes cannel coal. (m) Includes a small quantity made from spelter. (n) Average price at New York. (o) Flasks of 76.5 lb. (p) Average value of Lake copper at New York, less 0.25c. per pound. (q) Includes spiegeleisen, although the value is reckoned as if the whole product was ferromanganese. (r) Includes estimate of $140,000 for metals not enumerated.

Metals and Alloys.

Aluminum.—The production of aluminum in the United States in 1903 was approximately 7,500,000 lb. ($2,325,000), as compared with 7,300,000 lb. ($2,284,590) in 1902.

Antimony.—The production of antimony from imported ores, including also the metal contained in hard lead from both foreign and domestic sources, was 6,174,000 lb. ($389,579), as compared with 6,464,000 lb. ($495,789) in the previous year.

Copper.—The production increased from 645,887,447 lb. ($75,161,922) in 1902 to 689,045,796 lb. ($90,726,660) in 1903. The greater part of the increase came from Arizona, Michigan and Utah. The output in California and Montana showed a falling off as compared with the totals for 1902.

Ferromanganese.—The production of ferromanganese, including spiegeleisen, was 192,661 long tons ($9,488,554), against 212,981 long tons ($13,852,199) in 1902.

Gold and Silver.—The domestic production of gold in 1903 was 3,560,000 troy oz. ($73,591,700), as compared with 3,870,000 troy oz. ($80,000,000) in the previous year. The output of silver amounted to 54,300,000 troy oz. ($29,-322,000), as compared with 55,500,000 troy oz. ($29,415,000) in 1902. The decrease in gold production was due mostly to the falling off in Colorado, although California, Oregon and New Mexico reported smaller totals than in the preceding year. The decline in silver output was also due in large part to the smaller yield of Colorado mines.

Iron.—The production of pig iron in 1903, exclusive of ferromanganese and spiegeleisen, was 17,608,326 long tons ($308,145,705), as compared with 17,-816,591 long tons ($285,965,456) in the previous year. Of the total for 1903 the output of bessemer pig amounted to 9,989,908 long tons, against 10,393,168 long tons in 1902, and of basic pig to 2,040,726 long tons, against 2,038,590 long tons in 1902.

Lead.—The domestic production in 1903 was 276,694 short tons ($23,447,-050), against 280,524 short tons ($22,829,043) in the previous year. There was a decrease in the output of desilverized lead, but the production of soft lead showed a slight gain. In addition to the domestic output, a total of 92,794 short tons of lead was made from foreign ores and bullion. The average price of lead at New York in 1903 was 4.237c. per lb., as compared with 4.069c. per lb. in 1902.

Molybdenum.—No statistics of molybdenum were collected in 1903, but the output in 1902 was 35,000 lb. ($62,125).

Nickel.—There was no production of nickel from domestic ores in 1903, as compared with an output of 5,748 lb. ($2,587) in 1902. No statistics are available in regard to the quantity of nickel made from foreign ores, but in 1902 the production was 10,391,478 lb. ($4,520,293).

Platinum.—There was a production of 110 troy oz. of platinum ($2,080) in 1903, against 94 troy oz. ($1,814) in the previous year.

Quicksilver.—The production of quicksilver increased from 34,804 flasks ($1,515,714) in 1902 to 37,123 flasks ($1,564,734) in 1903. California contributed 32,094 flasks to the total last year and Texas the remainder, the mines in Oregon having made no production.

Tungsten.—No data are available as to the output of tungsten in 1903, but the production in 1902 amounted to 82,000 lb. ($50,020).

Zinc.—The production in 1903 amounted to 158,502 short tons ($17,118,-216), as compared with 158,237 short tons ($15,317,342) in 1902. There was little change in the relative outputs from the different districts. The average price of spelter at New York was 5.40c. per lb. in 1903, against 4.84c. in 1902.

Ores, Minerals and Chemical Products.

Arsenic.—The production of arsenious oxide in 1903 amounted to 611 short tons ($35,028), against 1,353 short tons ($81,180) in the preceding year.

Asbestos.—The production of asbestos in 1903 was 874 short tons ($14,160), as compared with 1,010 short tons ($12,400) in 1902. Almost the entire output in both years was contributed by one mine in Georgia.

Asphaltum.—The total output of asphaltic products in the United States in 1903 was 101,255 short tons ($1,005,446), against 98,880 short tons ($746,-341) in the previous year. The production of bituminous sandstone amounted to 38,633 tons ($118,001), against 57,837 tons ($157,093) in 1902. Of asphaltic limestone the output was 2,520 tons ($8,800), against 1,859 tons ($7,782) in 1902. The production of hard asphaltum was 53,552 tons ($678,-756), as compared with 35,132 tons ($455,854) in the previous year. The production of gilsonite in Utah amounted to 5,619 tons ($188,357), against 4,052 ($125,612) in 1902. In addition to these materials there was also produced 961 tons of mastic ($11,532) in 1903.

Barytes.—The production in 1903 was 50,397 short tons ($152,150), against 58,149 short tons ($186,713) in the previous year. Missouri contributed the largest output in 1903, the remainder being obtained from Tennessee, North Carolina and Virginia.

Bauxite.—The production in 1903 amounted to 48,087 long tons ($171,306), as compared with 29,222 long tons ($128,206) in 1902. The large gain in output was due to unusual activity in the bauxite district of Arkansas.

Bromine.—The production of bromine, including the quantity of bromine contained in potassium bromide, in 1903 was 597,000 lb. ($170,145), against 513,913 lb. ($128,472) in the previous year.

Calcium Borate.—The production in 1903 was 34,430 short tons ($661,400), against 20,004 short tons ($2,538,614) in the previous year. The statistics for 1903 represent crude borax, while those for 1902 include 17,404 short tons ($2,447,614) of crude material.

Carborundum.—The production of carborundum in 1903 was 4,760,000 lb. ($476,000), against 3,741,500 lb. ($374,150) in the previous year.

Cement.—The total production of cement of all kinds in the United States during 1903 amounted to 29,899,140 bbl. ($31,931,341), against 25,753,504 bbl. ($25,366,380) in the previous year. Of the totals given, 22,342,973 bbl. ($27,713,319) in 1903, and 17,230,644 bbl. ($20,864,078) in 1902, were portland cement; 7,030,271 bbl. ($3,675,520) and 8,044,305 ($4,076,630), respectively, natural rock cement; and 525,896 bbl. ($542,502) and 478,555 bbl. ($425,672) slag cement. The production of portland cement in 1903 was distributed by States as follows: Pennsylvania, 9,754,313 bbl. ($11,205,892); New Jersey, 2,693,381 bbl. ($2,944,604); Michigan, 1,955,183 bbl. ($2,674,-780); New York, 1,602,946 bbl. ($2,031,310); Illinois, 1,257,500 bbl. ($1,914,500); Indiana, 1,077,137 bbl. ($1,347,397); Kansas, 1,019,682 bbl. ($1,285,310); other States, 2,982,831 bbl. ($4,309,126). The principal producers of natural rock cement in the same year were: New York, 2,417,137 bbl. ($1,510,529); Indiana-Kentucky, 1,533,573 bbl. ($766,786) and Pennsylvania, 1,339,090 bbl. ($576,269).

Chrome Ore.—There was a production of 150 long tons ($2,250) of chrome ore in 1903, against 315 long tons ($4,725) in the preceding year. California contributed the entire output in both years.

Clay.—The total value of brick and other clay products made in the United States in 1903 was $130,962,648, as compared with $122,169,531 in the previous year. The different materials entering into the statistics given, together with their values for 1903 and 1902, respectively, are as follows: Common brick, $50,532,075, against $48,885,869; front brick, $5,308,908, against $5,318,008; vitrified paving brick, $6,453,849, against $5,744,530; fancy or ornamental brick, $322,567, against $335,290; enameled brick, $569,689 against $471,163; fire brick $14,062,369, against $12,601,435; drain tile, $4,639,214, against $3,506,787; sewer pipe, $8,525,369, against $7,174,-892; ornamental terra cotta, $4,672,028, against $3,526,906; fireproofing, $3,861,343, against $3,175,593; tile (not drain), $3,505,329, against $3,622,-863; pottery, $25,436,052 against $24,127,453. Of the various States contributing to the output in 1903, Ohio ranks first, with a total of $25,208,128; Pennsylvania second, with a total of $18,847,324, and New Jersey third, with a total of $13,416,939.

Coal and Coke.—The total production of coal in the United States in 1903 was 352,365,192 short tons ($485,175,762), as compared with 299,823,254 short tons ($368,576,568) in 1901. The production of anthracite, most of it from Pennsylvania, was 75,288,206 short tons ($158,100,232), against 41,451,-267 short tons ($83,002,229) in 1902. The output of cannel coal is included under bituminous. The output of bituminous coal, of which Pennsylvania and the Central States are the largest producers, was 277,076,986 short tons ($327,-075,530), as compared with 258,371,987 short tons ($285,574,339) in 1902. This was an increase in the output of nearly every important coal-producing State. The total quantity of coke made in 1903 was 25,262,360 short tons ($66,459,623), against 23,106,059 short tons ($52,116,741) in 1902.

Cobalt Oxide.—No statistics are available as to the production of cobalt oxide in 1903. The output in the previous year amounted to 20,870 lb. ($45,-450).

Copperas.—The production in 1903 amounted to 20,240 short tons ($121,-440), against 19,784 short tons ($118,474) in the previous year. The largest producer is the United States Steel Corporation, which controls most of the wire and sheet-steel works, recovering copperas as a by-product. The above statistics do not include the amounts converted into venetian and indian reds at the works of original production.

Copper Sulphate.—The production of copper sulphate in 1903 amounted to 43,124,454 lb. ($1,811,227), against 48,763,538 lb. ($2,028,563) in the previous year. These totals include the product made from ore and metallic copper, as well as that recovered by refiners.

Emery and Corundum.—The production of emery and corundum in the

United States in 1903 was 2,542 short tons ($64,102), against 4,251 short tons ($104,605) in 1902.

Feldspar.—The production in 1903 was 41,891 short tons ($256,733), against 45,287 short tons ($250,424) in the previous year.

Fluorspar.—The output was 42,523 short tons ($213,617) against 48,018 short tons ($271,832) in 1902.

Fullers Earth.—The output in 1903 was 11,280 short tons ($77,570), as compared with 14,100 short tons ($109,980), in the previous year.

Garnet.—The production of garnet for abrasive purposes amounted to 4,413 short tons ($146,955) in 1903, against 3,722 short tons ($122,826) in 1902. A large part of the output in both years came from the mines near North Creek, New York.

Graphite.—The production of crystalline graphite was 4,525,700 lb. ($164,-247), against 4,176,824 lb. ($153,147) in 1902. The output of amorphous graphite amounted to 16,591 short tons ($71,384), against 4,739 short tons ($555,964) in 1902. As in previous years, the larger part of the crystalline product came from the mines in the Adirondack region of New York. The single manufacturer of artificial graphite reported an output of 2,620,000 lb. ($178,670), as compared with 2,358,828 lb. ($110,700) in 1902.

Gypsum.—The production of gypsum in 1903 was 1,041,704 short tons ($3,792,943), against 816,478 short tons ($2,089,341) in the previous year. The figures of production represent crude material, while the values are based on the different marketable products, of which wall plaster and plaster-of-paris are the most important.

Iron Ore.—The production in 1903 was 32,471,550 long tons ($55,201,635), against 34,636,121 long tons ($64,796,546) in the previous year. Of the totals given 24,099,550 long tons in 1903, and 27,571,121 long tons in 1902, were produced by the Lake Superior districts.

Limestone for Iron Flux.—Iron smelters consumed 12,029,719 long tons ($5,423,732) of limestone in 1903, as compared with 12,139,248 long tons ($5,271,252) in the previous year.

Magnesite.—The production of magnesite in 1903 was 3,744 short tons ($10,-595), against 3,466 short tons ($21,362) in the previous year. The entire output of this mineral is derived from California.

Mica.—The production of sheet mica in 1903 amounted to 90,100 lb. $17,-128), as compared with 373,266 lb. ($83,843) in the previous year. The output of scrap mica was 1,693 short tons ($41,990), against 1,028 short tons ($13,081) in 1902.

Monazite.—The output in 1903 was 862,000 lb. ($64,630), against 802,000 lb. ($64,160) in the previous year.

Natural Gas.—The value of the natural gas output in 1903 was $35,815,360, against $30,867,863 in the previous year. It is estimated that the production for 1903 was equivalent in heating value to 12,000,000 tons of bituminous coal.

Ocher and Oxide of Iron Pigments.—The production of ocher, umber, sienna and natural oxide of iron ground pigment, the last being commonly known as metallic paint, was 62,122 short tons ($646,222), against 73,049 short tons ($944,332) in 1902. Pennsylvania is the largest producer of these pigments.

Petroleum.—The output of petroleum in 1903 was 100,496,400 bbl. ($94,-330,000), against 89,184,497 bbl. ($71,536,425) in 1902. The great increase shown by these totals was due for the most part to the remarkable expansion in the California oil-fields, which contributed 24,340,839 bbl. in 1903, as compared with 14,356,910 bbl. in the previous year. Indiana, Kansas, Louisiana and Kentucky also reported increases in 1903. The output of Texas remained nearly stationary, while that of the Appalachian field showed a decline.

Phosphate Rock.—The production of phosphate rock in 1903 amounted to 1,570,228 long tons ($4,993,912), as compared with 1,600,813 long tons ($5,-041,362) in the previous year. The output in 1903 was distributed by States as follows: Florida, 764,703 long tons ($2,560,458); North Carolina, 30,000 long tons ($22,500); South Carolina, 335,015 long tons ($963,794); Tennessee, 445,510 long tons ($1,434,660); other States, 5,000 long tons ($12,500).

Precious Stones.—The value of the precious stones produced in the United States in 1903 was $321,400, against $328,450 in 1902.

Salt.—The output in 1903 was 18,968,089 bbl. ($5,286,988), against 23,-849,231 bbl. ($5,668,636) in the previous year.

The States contributing to the total in 1903, with the output and value of their product, were as follows: New York, 8,170,648 bbl. ($2,007,807); Michigan, 4,297,542 bbl. ($1,119,984); Kansas, 1,555,934 bbl. ($564,232); Ohio, 2,798,899 bbl. ($795,897); California, 629,701 bbl. ($198,630); Texas, 314,-000 bbl. ($117,647); West Virginia, 244,236 bbl. ($35,797); Utah, 212,955 bbl. ($181,710); Louisiana, 568,936 bbl. ($178,342); other States, 175,238 bbl. ($86,942). The imports of salt for the year 1903 were 331,961,807 lb. ($495,948), and the exports 25,499,630 lb. ($95,570).

Silica.—The production of flint or quartz in 1903 was 55,233 short tons ($156,947), against 36,365 short tons ($144,209) in the previous year. Of quartz sand the output was 2,110,660 short tons ($1,831,210) in 1903, and 1,847,901 short tons ($1,423,614) in 1902. The production of pumice was 885 short tons ($2,665) in 1903, against 700 short tons ($2,750) in 1902. The production of diatomaceous earth amounted to 9,219 short tons ($76,273), against 5,665 short tons ($53,244) in 1902. Of millstones, grindstones and whetstones the production was as follows: millstones, $52,552 against $59,808; grindstones, $721,446 against $667,431; whetstones, $69,909 against $32,980.

Slate.—The production of roofing slate was 1,378,194 squares ($5,400,078), against 1,435,168 squares ($4,950,428) in 1902. The output of slate manufactures was valued at $856,807, as compared with 745,623 in the previous year.

The production of roofing slate in 1903 was contributed by the following States: Arkansas, 118 squares ($709); California, 10,000 squares ($70,000); Maine, 27,377 squares ($157,911); Maryland, 24,475 squares ($135,424); New York and New Jersey, 23,337 squares ($122,951); Pennsylvania, 871,875 squares ($3,378,804); Vermont, 391,366 squares ($1,418,923); Virginia, 29,-646 squares ($115,356). Of slate manufactures the detailed statistics were as follows: Arkansas, $4,000; Maine, $73,319; Maryland, $2,207; New York, $22,450; Pennsylvania, $581,102; Vermont, $173,729.

Stone.—The total value of all kinds of stone produced in the United States in 1903 was $67,960,468, against $64,559,099 in 1902. These totals do not include the output of limestone used as furnace flux, which amounted to 12,-029,719 long tons ($5,423,732) in 1903, and 12,139,248 long tons ($5,271,-252) in 1902. Classified according to variety, the output in 1903 and 1902 was as follows: Granite, $15,703,793, against $16,076,787; trap rock, $2,732,-294, against $2,181,157; marble, $5,362,686, against $5,044,182; slate, $6,256,-885, against $5,696,051; sandstone, $9,482,802, against $4,437,646; bluestone, $1,779,457, against $1,163,525; limestone, $26,642,551, against $24,959,751. The principal producing States in 1903 were Pennsylvania, with a total output of $13,913,220; Vermont, with an output of $6,605,060; New York, with an output of $5,742,833, and Ohio, with an output of $5,114,051.

Sulphur and Pyrite.—There was a production of 35,098 long tons ($789,-738) of sulphur in 1903, against 7,443 long tons ($169,746) in the previous year. The output for 1903, the largest ever recorded in this country, was contributed by Louisiana, Nevada and Utah. The production of pyrite amounted to 199,387 long tons ($787,579), as compared with 228,198 long tons ($971,-796) in 1902. The total consumption of sulphur in the United States, including the sulphur contents of domestic and imported pyrite, was 508,578 long tons, against 489,081 long tons in 1902.

Talc and Soapstone.—The production of fibrous talc amounted to 32,230 short tons ($225,600) in 1903, against 71,100 short tons ($615,350) in 1902. Of common talc and soapstone the output was 26,671 short tons ($418,460), against 26,854 short tons ($525,157) in the previous year.

Tungsten Ore.—No statistics are available as to the production of tungsten ore in 1903, but in the previous year the output amounted to 221 long tons ($38,600).

White Lead, Red Lead and Litharge.—The production of lead pigments was as follows: white lead, 112,700 short tons ($12,228,024) in 1903, against 114,-658 short tons ($11,978,172) in 1902; red lead, 12,300 short tons ($1,385,-900), in 1903, against 11,669 short tons ($1,262,712) in 1902; litharge, 12,400 short tons ($1,326,800) in 1903, against 12,755 short tons ($1,299,443) in 1902; orange mineral, 1,000 short tons ($168,000) in 1903, against 867 short tons ($138,349) in 1902.

Zinc-Lead.—The output of the special pigment, known as zinc-lead, in 1903, amounted to 4,500 short tons ($253,125), against 4,000 short tons ($225,000) in the previous year. The production in both years was made by a single concern, the American Zinc-Lead Company of Cañon City, Colorado.

Zinc Ore.—The quantity of zinc ore exported from the United States in 1903 was 39,418 short tons ($987,000), as compared with 55,733 short tons ($1,449,104) in 1902.

Zinc White.—The output of zinc white in 1903 was 54,034 short tons ($5,005,394), as compared with 52,730 short tons ($4,023,299) in 1902. A large part of the production of zinc white in the United States is made by the New Jersey Zinc Company.

ALUMINUM.

The production of aluminum in 1902 was 7,300,000 lb., valued at $2,284,590. No exact information is available relative to the output in 1903, as the Pittsburg Reduction Company, which is the only manufacturer of aluminum in the United States, declines to publish its figures. It may be assumed, however, that there was a moderate increase during the past year in accordance with the enlarged output of bauxite in this country and the general expansion of the consumption of aluminum for industrial and other purposes. The new plant of the Pittsburg Reduction Company at Massena Springs, N. Y., was completed in September, 1903, and placed in operation. Power is supplied by the St. Lawrence Power Company, which has erected a 50,000-h. p. hydraulic works on the Grasse river. The equipment of the new plant includes four 300-h. p. generators, but it is intended to increase the capacity, as the demand for aluminum grows, to 12,000 h. p. Departments for the manufacture of the carbon electrodes used in the furnaces have been installed at both Niagara Falls and Massena Springs, and a wire mill is under construction at the latter locality.

PRODUCTION, IMPORTS, AND CONSUMPTION OF ALUMINUM IN THE UNITED STATES.

Year.	Production.			Imports. (b)	Exports.	Consumption. (a)
	Pounds.	Value.	Per Lb.	Value.	Value.	Value.
1899	6,500,000	$2,112,500	$0.325	$14,840	$291,515	$1,835,825
1900	7,150,000	2,288,000	0.32	47,688	281,821	2,053,847
1901	7,150,000	2,238,000	0.31	104,168	183,579	2,158,589
1902	7,300,000	2,284,590	0.31	215,032	116,052	2,383,570
1903	*e* 7,500,000	2,325,000	0.31	143,571	157,187	2,311,384

(*a*) The consumption each year includes a certain amount of manufactures imported; while the production represents the crude aluminum only. (*b*) The bulk of the imports is in crude condition.

The chief point of interest affecting the aluminum industry in the United States during the year was the final adjudication of the litigation between the Electric Smelting & Aluminum Company and the Pittsburg Reduction Company. Suits and counter-suits were brought on behalf of the two companies, from time to time, until finally in October, 1903, the United States Circuit Court of Appeals rendered a decision against the Pittsburg Company for infringement of patents since 1892, involving a sum very near $3,000,000. A compromise was effected on October 31, 1903, between the contesting concerns, whereby a large sum of money was paid by the Pittsburg Reduction

Company for past infringement of the Bradley patents controlled by the Electric Smelting & Aluminum Company, and an agreement was then entered into by which the Pittsburg Reduction Company was to continue the manufacture of aluminum under license of the Bradley patents until their expiration in February, 1909, paying a royalty on all metal produced. By the terms of the agreement the Electric Smelting & Aluminum Company will restrict its operations to the manufacture of alloys, although it may handle and sell aluminum in all forms at the works in Lockport, N. Y. The settlement involves, also, an agreement by the Electric Smelting & Aluminum Company not to appeal the old case of the Pittsburg Reduction Company vs. the Cowles Electric Smelting & Aluminum Company, wherein the latter company was enjoined by the United States Circuit Court from manufacturing aluminum metal.

ALUMINUM: WORLD'S PRODUCTION AND COMMERCE. (IN KILOGRAMS.)

Year.	Germany.	Switzerland.		England.	France.			United States. (a)		Total Production.
	Imports.	Production.	Exports	Production.	Production.	Imports	Exports	Production.	Imports	
1897....	942,400	800,000	706,000	(b)310,000	470,000	6,360	224,000	1,814,388	854	3,394,448
1898....	1,104,000	800,000	677,300	310,000	565,000	5,972	187,955	2,358,705	27	4,033,705
1899....	922,000	1,300,000	604,200	559,000	763,000	8,468	256,242	2,948,381	24, 323	6,570,389
1900....	943,400	2,500,000	571,200	568,960	1,026,000	8,300	323,700	3,243,219	116,353	7,338,173
1901....	1,089,600	2,500,000	504,100	560,000	1,200,000	11,400	306,600	3,243,219	255,696	7,503,219
1902....	1,100,000	2,500,000	523,800	600,000	1,355,000	10,900	748,200	3,312,258	337,583	7,767,248

(a) The United States has been an exporter of aluminum for several years, but these exportations were not enumerated by the Bureau of Statistics of the Treasury Department until 1898, in which year they amounted to $239,997. (b) C. Le Neve Foster, British Mineral Statistics for 1897.

There are three producers of aluminum in Europe, as follows: The British Aluminum Company, with works at Foyers, Scotland; the Société Electro-Métallurgique Française, with works at Froges and La Praz, France; and the Aluminum-Industrie Aktien Gesellschaft, which has works at Neuhausen, Switzerland, Lend-Gastein, Austria and Rheinfelden, Germany. The last-named company is the largest producer, and has recently extended its Austrian works.

Prices.—The prices quoted for the different grades of aluminum during 1903 were practically the same as in the previous year. They were as follows, in cents, per pound:

	Small Lots.	100-lb. Lots.	1000-lb. Lots.	2000-lb. Lots.
No. 1 (99.75% Al)........	3	35	34	33
No. 2 (90+% Al)........	34	33	32	31
Nickel-Aluminum Casting Metal (10% Ni)........	39	35	34	33
Special Casting Alloy (80% Al)........	35	30	29	27

A New Aluminum Process.—A patent[1] secured by G. Gin, of Paris, describes the following process for the manufacture of aluminum: Bauxite is treated with a solution of hydrofluoric acid in sufficient quantity to combine with all its component parts so as to form aluminum fluoride (first element of the electrolyte) as well as iron fluoride and the fluosilicates and fluotitanates of aluminum, the silica. the titanic acid, and the iron being subsequently precipitated by an addition of alumina. The hydrofluoric acid is obtained by the decomposition of the sodium fluoride, which is the residue of the electrolysis, the decomposition being effected by means of the sulphuric acid recuperated through the oxidation of the sulphur disengaged at the anode. The sodium sulphide (second element of the electrolyte) is made by reducing the sodium sulphate resulting from the decomposition of sodium fluoride by sulphuric acid, the various operations thus constituting a continuous closed cycle. Aluminum is produced by decomposing with an electric current an electrolyte formed by a molten mixture in definite proportions of aluminum fluoride and sodium sulphide.

Thermit.—One of the most promising fields for the consumption of aluminum is the so-called thermit process invented by Hans Goldschmidt, which produces an intense heat by the oxidation of metallic aluminum in intimate contact with metallic oxides. Thermit consists mainly of a mixture of iron oxide and aluminum in nearly equivalent quantities. The heat produced by the chemical reaction of the two substances has been utilized for various purposes, such as for welding in place steel rails or broken iron or steel castings; for reducing refractory oxides of rarer metals, including tungsten, chromium and molybdenum; and for preventing the formation of large pipes in the tops of steel ingots. The use of thermit in the welding of tramway rails is rapidly extending, especially in England and Germany. For the conduction of the electric current, especially in trolley lines, the great advantage of welding both the track and the third rails is obvious, since the ends of adjacent rails may be welded together without removal from the track at a cost stated to be less than the usual connection by means of fish-plates and copper binding wires; and when the rails of a track are welded in this manner they are practically continuous and the connections permanent, which avoids the frequent and costly repairs so necessary to maintain a perfectly good conductor for the electric current. During 1903 no less than 20,000 track joints were made by the thermit welding process. The system has been introduced in the cities of Leeds, Glasgow and Nottingham, and an English company is using the process for welding 25 miles of rails in Singapore. For the welding of wrought iron pipes the thermit process has also been largely used. Joints made in this way are said to be cheaper than the usual flange joint, and are especially serviceable when the pipes or tubes are subjected to high pressure or when they

1 English Patent No. 964, January 14, 1903.

are used for transport of liquids, such as alkalis and petroleum, which attack the materials commonly used for packing.

Electrical Conductors.—According to R. J. Parke[2] aluminum possesses several advantages over copper for electrical conductors; it costs less for transportation and erection, its durability is greater and the expense of maintenance is less on account of the smaller strains to which poles, cross-arms and insulators are subjected. On the other hand, the use of aluminum involves a good deal of difficulty in making joints, besides a greater sag due to the larger coefficient of expansion, while wires of sizes used for telephone and telegraph lines do not possess sufficient strength to be employed for these purposes. The following data may be used in comparing the qualities of commercial aluminum and hard-drawn copper in ordinary sizes:

	Aluminum.	Copper.		Aluminum.	Copper.
Specific gravity	2.68	8.93	Cross-section for equal resistance	1.56	1
Conductivity (Matthiessen standard)	62.00	97.00	Diameter for equal resistance	1.25	1
Tensile strength per square inch	28,000	45,000	Weight for equal resistance	0.47	1
Coefficient of linear expansion	0.0000128	0.0000093	Tensile strength for equal resistance	0.96	1
Coefficient of temperature resistance	0.00114	0.00117	Price for equal cost	2.13	1
Modulus of elasticity	9,000,000	14,000,000	Rate of temperature change	1	1

Aluminum Alloys.—A résumé of the progress that has been made in the manufacture of aluminum alloys was given by Joseph W. Richards.[3] According to this authority the chromium-aluminum alloys have somewhat the qualities of self-hardening steel, retaining their hardness on heating or after annealing. The use of 2.3 per cent chromium makes a good alloy; 11 per cent gives a brittle alloy. The alloys with chromium are being used. Titanium-aluminum alloys have practically gone out of use owing to the difficulty connected with their manufacture. Alloys of aluminum and manganese, up to 5 per cent manganese, are hard and rigid; with copper and nickel, manganese makes the hardest light alloy yet produced. The manganese should be employed in the form of a rich aluminum manganese alloy produced in the electric furnace. Alloys of tin and aluminum are not much used. The aluminum-silver alloys are harder, stronger and whiter than pure aluminum and take a higher polish; they are used for making table-ware and ornamental articles. The commercial alloys which come under the name of nickel-aluminum are really alloys of aluminum, nickel and copper. The effects of tungsten on aluminum have not been satisfactorily determined. An aluminum alloy containing a small amount of tungsten has been used extensively for manufacturing military equipments. Aluminum alloyed with 2 or 3 per cent of

2 Paper read before the Canadian Electrical Association, Hamilton, Ontario.

3 Paper read before the American Society for Testing Materials, Delaware Water Gap, July 3, 1903.

German silver gives a strong, tough metal which is easily made. An aluminum alloy containing 10 per cent manganese is being used in Europe. Zinc is the cheapest and one of the most efficient metals with which to improve the mechanical qualities of aluminum. When the zinc does not exceed 15 per cent the alloys are malleable, but in castings as much as 33 per cent zinc may be used.

In the preparation of aluminum alloys the best results are obtained by the use of pure metals, this being especially the case with respect to zinc. In general the aluminum should first be melted and the other metal subsequently stirred in. The melting can be performed in an ordinary graphite crucible, although magnesia-lined crucibles are best for the work. It is important that the metal should not be overheated. The wrought iron stirring rod may be used, but a carbon rod with an iron pipe for a handle is better. The alloys should be allowed to cool down before pouring. The use of a flux in the melting is not recommended. For general castings green sand is suitàble. Slabs and rods for rolling or drawing are cast in chill moulds, as the metal is soft, uniform and stronger than if cast in sand. Since the alloys harden and soften by working, they must be frequently annealed during rolling. Slabs or billets are best broken down by a steel hammer while at a temperature of 150° to 250° C.; steel rollers with good surfaces should be used, and the rollers should be at a temperature of 150° to 200° C.

ANTIMONY.

There was no production of metallic antimony from domestic ores during 1903. The removal of the former duty of 20 per cent *ad valorem* on imports of crude antimony into the United States permits the treatment of foreign ores on a basis with which the domestic industry can not compete. The foreign ores are imported also at a low transport rate, whereas many of the deposits in this country are so situated that long shipments by rail are necessary to reach the consuming markets. The control of the antimony refining industry in the United States is in the hands of Mathison & Company, who have a plant at Chelsea, New York. The Chapman Smelting Company, of San Francisco, has produced a small quantity of antimony from domestic ores in former years, but the works have been shut down since 1902.

The imports of antimony regulus or metal in 1903 were 5,125,515 lb., valued at $279,957, and the exports 79,917 lb., valued at $4,478. Of antimony ores and crude antimony (partly refined stibnite) the imports were 2,673,472 lb. valued at $51,489; there were no exports.

The quantity of hard, or antimonial lead produced in the United States during 1903 from the smelting of impure foreign and domestic lead ores, amounted to 9,453 short tons, the estimated content of which was 2,552 tons antimony; in 1902 the output was 10,485 tons lead containing 2,904 tons antimony. Hard lead is used largely in the manufacture of anti-friction metal and other alloys. It contains from 18 to 27 per cent antimony.

IMPORTS, EXPORTS, PRODUCTION AND CONSUMPTION OF ANTIMONY IN THE UNITED STATES.

Year.	Imports.					Exports.			
	Metal or Regulus.		Ore.		Total Value.	Metal or Regulus.		Ore.	
	Pounds.	Value.	Pounds.	Value.		Pounds.	Value.	Pounds.	Value.
1899	3,160,697	$240,988	3,982,133	$47,841	$288,829	16,815	$1,275	*Nil.*	....
1900	3,632,843	285,749	6,035,734	78,581	364,330	23,520	2,352	*Nil.*	....
1901	3,674,923	255,346	1,731,956	24,256	278,597	*Nil.*	....	49,655	$1,536
1902	5,742,703	397,899	1,639,043	29,476	377,375	73,184	2,710	208,531	4,602
1903	5,125,515	279,957	2,673,472	51,489	331,446	79,917	4,478	*Nil.*	....

Year.	Production.			Imports on Basis of Antimony Metal.	Consumption.
	In Hard Lead. (*a*)	From Domestic Ores.	From Imported Ores. (*a*)		Total. Supply.
	Short Tons.	Short Tons.	Short Tons.	Short Tons.	Short Tons.
1899	1,586	234	1,041	1,495	4,356
1900	2,476	151	1,599	1,827	6,053
1901	2,235	50	364	1,837	4,486
1902	2,904	*Nil.*	328	2,871	6,103
1903	2,552	*Nil.*	535	2,563	5,620

(*a*) Estimated 40% extraction from net import of ore.

The antimony market showed a declining tendency throughout the year. In the opening month Cookson's was quoted at 8¼c., Hallet's at 7c., and Hungarian, U. S. Star and other brands at 6¾c. By the beginning of March the prices for Hallet's fell to 6⅞c., and Hungarian to 6½c. In May another decline was recorded, Cookson's selling at 7½c., Hallet's at 6¾c., and Hungarian at 6½c. Further reductions were recorded in the following months, and the year closed with Cookson's at 6¾c., Hallet's at 6½c., and Hungarian at 5¾c.

AVERAGE MONTHLY PRICES OF ANTIMONY IN NEW YORK. (IN CENTS PER POUND.)

Year.	Brand.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year
1899 ..	Cookson's......	9.31	10.25	10.37	10.10	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.37
	Hallett's.......	8.81	9.62	9.75	9.80	10.00	10.00	10.00	9.81	9.65	9.72	9.75	9.75	9.67
	U. S. Star......	8.81	9.62	9.75	9.80	10.00	10.00	9.81	9.81	9.56	9.50	9.50	9.50	9.65
	Chapman's.....	....	9.62	9.75	9.80	10.00	10.00	10.00	....	....	....	....	....	....
	Hungarian.....	....	....	9.75	9.80	10.00	10.00	....	9.75	9.56	9.50	9.50	9.50	....
1900 ..	Cookson's......	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.10	10.00	10.00	10.00	10.34
	Hallett's.......	9.75	9.75	9.75	9.75	9.69	9.62	9.53	9.50	9.30	9.25	9.25	9.25	9.25
	U. S. Star......	9.50	9.50	9.50	9.50	9.50	9,50	9.50	9.50	9.30	9.25	9.25	9.25	9.43
1901 ..	Cookson's......	10.00	10.00	10.00	10.31	10.25	10.25	10.25	10.25	10.12	10.09	10.00	10.00	10.12
	Hallett's.......	9.12	9.22	8.90	8.94	8.75	8.75	8.75	8.43	8.50	8.47	8.37	8.31	8.74
	U. S. Star......	9.25	9.06	8.80	8.73	8.63	8.63	8.63	8.50	8.37	8.34	8.25	8.00	8.69
	Hungarian.....	....	8.75	8.75	8.73	8.63	8.63	8.63	8.50	8.37	8.34	8.25	8.00	8.51
	Italian.........	....	8.75	8.75	8.73	8.63	8.63	8.63	8.50	8.37	8.34	8.25	8.00	8.51
	Japanese.......	....	....	....	8.73	8.63	8.63	8.63	8.50	8.37	8.34	8.25	8.00	8.48
1902 ..	Cookson's......	10.00	10.00	9.87	9.87	9.87	9.87	9.75	9.75	9.69	9.44	9.25	9.20	9.71
	Hallett's.......	8.17	8.04	8.06	8.06	8.17	8.25	8.25	8.15	7.92	7.72	7.44	7.25	7.96
	U. S. Star......	7.86	7.75	7.75	7.75	7.90	8.00	8.00	7.90	7.65	7.37	7.22	6.92	7.67
	Hungarian.....	7.86	7.75	7.75	7.75	7.90	8.00	8.00	7.90	7.65	7.37	7.22	6.92	7.67
	Italian.........	7.86	7.75	7.75	7.75	7.90	8.00	8.00	7.90	7.65	7.37	7.22	6.92	7.67
	Japanese.......	7.86	7.75	7.75	7.75	7.90	8.00	8.00	7.90	7.65	7.37	7.22	6.92	7.67
1903 ..	Cookson's......	8.25	8.25	8.25	8.25	8.00	7.50	7.44	7.15	7.00	7.00	6.56	6.75	7.53
	Hallett's.......	7.00	7.00	6.87	6.87	6.75	6.69	6.50	6.40	6.34	6.25	6.25	6.35	6.69
	Other brands....	6.75	6.62	6.50	6.50	6.50	6.44	6.25	6.19	6.00	6.00	6.00	5.95	6.31

China.—In recent years China has become an important producer of antimony ores. The mines are situated in the Hankow district, 1,000 miles west of Shanghai. The crude ore is transported by boats to Hankow, where it is smelted to the so-called "Chinese needle antimony," which contains about 72 per cent antimony. The smelting works are owned by Carlowitz & Company. In 1903 the exports from Hankow were 6,666 long tons, valued at $420,440. The product is shipped to Shanghai for export to Hamburg, London and New York.

France.—The production of antimony ore in 1902 amounted to 9,715 metric tons, valued at $149,164. The principal mines, of which there were 16 in active operation, are situated in the departments of Mayenne, Haute-Loire, Corsica, Creuse, Lozère, Cantal and Ardèche. There are three smelting works situated at Conches, Blesle and Biroude. The ore is low grade and is roasted in a special furnace to produce the volatile antimonous oxide, which is collected in a condensation chamber. The product is used in part for the preparation of antimony compounds which are exported and in part for the production of metal.

New South Wales.—Antimony ore is produced in connection with gold mining in the Hillgrove district. The industry has been quite important in years past, but recently it has declined to less than 100 tons per year. In 1903 the quantity of ore exported amounted to 13 long tons valued at $875.

WORLD'S PRODUCTION OF ANTIMONY ORE (IN METRIC TONS).

Year.	Austria.		Bolivia.		France and Algeria.		Hungary.		Italy.		Japan.	Mexico. (a)	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Tons.	Value.
1898	679	$22,867	591	221,725	4,571	$69,462	2,201	$20,219	1,931	$43,822	1,006	5,932	$98,815
1899	410	15,244	1,213	454,866	7,592	130,493	1,965	34,205	3,791	44,862	712	10,382	115,292
1900	201	7,065	1,174	440,775	7,963	115,978	2,373	37,720	7,609	72,468	81	2,313	23,319
1901	126	4,557	190	38,309	9,867	156,834	1,691	19,500	8,818	68,513	119	5,103	51,064
1902	18	654	126	7,917	9,715	149,164	200	3,240	6,116	51,677	(d)	1,279	12,798

Year.	New South Wales. (b)		New Zealand.		Portugal.		Queensland.		Spain.		Turkey (c)	United States.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Tons.	Value.
1898	84	$4,580	*Nil.*	......	245	$6,736	*Nil.*	......	130	$2,149	(d)	(d)	......
1899	332	13,470	*Nil.*	......	59	2,123	41	$1,000	50	1,560	1,173	544	$20,000
1900	252	12,145	5	$505	38	554	*Nil.*	......	30	900	267	300	10,500
1901	90	5,915	30	680	126	2,650	*Nil.*	......	10	150	224	100	3,500
1902	57	2,710	*Nil.*	......	*Nil.*	......	*Nil.*	......	67	1,005	.....	.....	......

(a) Export figures, values in Mexican dollars. (b) Metal and ore. (c) Export figures. Of doubtful accuracy. (d) Statistics not available.

Estimation of Antimony in Lead.—A modification of Györy's method is described by H. Nisseusan and P. Siedler.[1] About one gram of the finely divided metal is treated with 20 c.c. of chlorhydric acid containing bromine, and is kept warm (with occasional shaking) until solution is complete. The solution is then boiled to drive off the bromine, after which it is cooled a little and two or three small crystals of sodium sulphite are added. The solution is then boiled again until all the sulphur dioxide is driven off, after which 20 c.c. of dilute chlorhydric acid are added. The solution is then titrated hot with decinormal potassium bromate, using three drops of a sulphuric acid solution of indigo as indicator. The potassium bromate is prepared by purifying the salt by a three times repeated crystallization, then drying it at 100° C., and finally over sulphuric acid in a desiccator. The solution is made up by dissolving 2.7852 grm. in a liter of water. In the titration of an unknown sample, three drops of the indigo indicator are used at the beginning. The blue color gradually changes into green and disappears. Three drops more of the indicator are then added, and the titration is continued until the end point is shown by the sudden disappearance of the color. A second portion of the same sample is then taken and the potassium bromate solution is run in nearly to the end point indicated by the first titration. The indicator is then added and the titration is continued to the end point. It is said that the impurities usually present in antimonial lead do not affect the process, results of which are accurate.

1 The Engineering and Mining Journal, December 10, 1903.

ARSENIC.

The production of arsenious oxide (white arsenic) in the United States during 1903 amounted to 611 short tons, against 1,353 short tons in the preceding year. The entire output was made by the Puget Sound Reduction Company, at Everett, Wash., which has recently passed into the control of the American Smelting & Refining Company. The manufacture of arsenic first began in this country in 1901. Prior to that date the supply was drawn mostly from Devon and Cornwall, England, and Freiberg, Germany. In 1899 the Canadian Gold Fields, Ltd., became a producer, and the output of the company has since increased largely

Among the important developments in the industry during the year 1903 was the incorporation of the United States Arsenic Mines Company of Pittsburg to work deposits situated in Floyd and Montgomery counties, Virginia. The mines are 17 miles from Christiansburg, on the Norfolk & Western Railroad, and about 30 miles from Roanoke. They are nearly at the summit of the Blue Ridge, 3,200 ft. above sea level. The ore is found in a series of fissure veins outcropping at various places on the surface. The principal vein is 3 ft. thick at the outcrop, but widens to 14 ft. at a depth of 120 ft. Twenty veins have been discovered over a distance of seven miles, and it is believed that the deposits are extensive enough to last for a long period. It is said that the ore runs from 25 to 35 per cent arsenic. The mine is opened by an adit driven into the mountain side for a distance of 217 ft., where it intersects the principal vein.

The ore as mined is conveyed to a Blake crusher and then passes by gravity to rolls, where it is finely pulverized. It is then charged into Howell-White furnaces, where the metal is volatilized, and the vapors are precipitated and further purified by sublimation. A building 300 by 70 ft. has been erected for the mills and furnaces besides dwelling houses, a blacksmith shop, laboratory, office, saw mill and other structures. The plant is equipped with a 125-h. p. Westinghouse engine, two 75-h. p. boilers, four dynamos (one of 75 h. p., one of 15 h. p. and two of 2 h. p.), a 10 by 20-in. Blake crusher, a 27-ft. Howell-White calcining furnace, a set of rolls for pulverizing the product, etc. The works are situated at Brinton, Va. Productive operations were begun on January 13, 1904, since which time the output has been about three tons of white arsenic per day. The plant is capable of turning out twice this amount when operated at full capacity.

The Mineral Creek Development Company reported the discovery of a large deposit of arsenic ore at Mineral creek, near Elba, Washington. Metallic arsenic is said to have been found at Washington Camp, Santa Cruz county, Arizona. The metal occurs in masses attached to the walls of small pockets in dolomitic limestone, and in some cases pieces weighing several pounds each were taken out.

Imports.—The quantity and value of the imports into the United States of white arsenic (arsenious oxide), metallic arsenic and arsenic sulphide are as follows: 1899, 9,040,871 lb. ($386,791); 1900, 5,765,559 lb. ($265,500); 1901, 6,989,668 lb. ($316,525); 1902, 6,110,898 lb. ($280,055); 1903, 7,146,362 lb. ($256,097).

New York Market.—The average monthly prices of white arsenic at New York during 1903 were as follows: January, 2.75@3.125c.; February, 2.75@3.125c.; March, 2.75@3.125c.; April, 3@3.25c.; May, 3@3.125c.; June, 3@3.125c.; July, 3@3.125c.; August, 2.625@3c.; September, 2.625@3c.; October, 2.9@3.25c.; November, 3@3.5c.; December, 3.125@3.25c. The average prices of red arsenic (imported from Germany) by months were: January, 6.75@7c.; February, 6.75@7c.; March, 6.5@7c.; April, 6.5@6.75c.; May, 6.5@6.75c.; June, 6.5@6.75c.; July, 6.5@6.75c.; August, 6.375@6.5c; September, 6.375@6.5c.; October, 6.375@6.5c.; November, 6.375@6.5c.; December, 6.375@6.5c.

THE WORLD'S PRODUCTION OF ARSENIC AND ITS COMPOUNDS. (METRIC TONS.)

Year	Canada. (a)		Germany. (b)		Italy. (c)	Japan.	Portugal.		Spain. (a)		United Kingdom. (a)		United States.	
	Tons	Value.	Tons	Value.	Tons	Tons	Tons	Value.	Tons	Value.	Tons	Value.	Tons	Value.
1898	*Nil.*	......	2,667	$253,528	215	7	751	$44,764	111	$13,320	'4,241	$268,935	*Nil.*	....
1899	52	$4,842	2,423	267,250	304	5	1,083	61,356	101	12,156	3,890	271,180	*Nil.*	....
1900	275	22,725	2,414	263,250	120	5	1,031	62,522	150	18,036	4,148	335,140	*Nil.*	....
1901	630	41,676	2,549	256,750	*Nil.*	10	527	35,277	120	14,400	3,416	197,270	272	$18,000
1902	726	48,000	2,828	260,000	*Nil.*	....	736	33,063	71	8,520	2,131	96,610	1,226	81,180

(*a*) Arsenious oxide. (*b*) Arsenic sulphide, arsenious oxide and other compounds. (*c*) Metallic arsenic and arsenious oxide. (*d*) Natural arsenic sulphide.

Canada.—The production of arsenic by the Canadian Goldfields, Ltd., in 1903 was 257 short tons, valued at $15,420, against 800 tons valued at $48,000 in 1902. The reduced output was due to the closing down of the mines in April, 1903, pending negotiations for the consolidation of the various arsenic properties in the vicinity of Deloro into a single concern. Such a consolidation would make possible an increased output at a reduced cost per ton. In connection with the extraction of arsenic, the ores of Deloro are treated for the recovery of gold by the Sulman-Teed bromo-cyanide process. A description of the methods employed by this company will be found in THE MINERAL INDUSTRY, Vol. XI.

Germany.—The production of arsenical compounds in 1903 was 2,768 metric tons, valued at $253,500, against 2,828 tons, valued at $260,000, in 1902.

Spain.—Natural arsenic sulphide (orpiment) is produced in the province of Oviedo, the output in 1903 being 22 tons, valued at $4,450. A new company, known as the Sociedad Girones y Henrich, entered upon the production of arsenical compounds in 1903. The plant is situated at Badalona, province of Barcelona, and is designed to treat auriferous mispickel and other refractory ores mined in the vicinity. In 1903 the output of arsenious acid was 1,088 metric tons, valued at $87,040.

Turkey.—Orpiment is mined at Allkhar, near Rozdan, the output being about 500 tons annually. Realgar and orpiment are mined in Macedonia and exported from Salonica. The exports from this port in 1902 were 50 tons.

United Kingdom.—The arsenic trade during 1903 was characterized by an unusual depression, which affected both the prices and production. There were 22 works in operation as compared with 35 in 1893. The output was 902 long tons, the lowest figure recorded in a long time. One of the largest works has been closed down, and the operations of the Devon Great Consols Company, renewed in 1903, were limited to the treatment of ore already mined and will be continued only for a short time.

ASBESTOS.

The production of asbestos in 1903 was 874 short tons, valued at $14,160, as compared with 1,010 short tons, valued at $12,400, in the previous year. As heretofore, the greater part of the output came from the deposits at Sall Mountain, White county, Ga., the remainder being furnished by the mines near Dalton, Massachusetts, and New Hartford, Conn. Excepting the small quantity produced in Massachusetts, the asbestos mined was of the amphibole variety, which is less valuable than the serpentine variety or chrysotile. Serpentine asbestos is known to occur in numerous localities in the United States, but so far it has not been mined in quantity.

PRODUCTION AND IMPORTS OF ASBESTOS IN THE UNITED STATES.

Year.	Production.			Imports.		
	Short Tons.	Value.	Value per Ton.	Manufactured.	Unmanufactured.	Total
1898	885	$13,425	$15.17	$12,899	$287,636	$300,535
1899	912	13,860	15.31	8,949	303,119	312,068
1900	1,100	16,500	15.00	24,155	331,796	355,951
1901	747	13,498	18.08	24,741	667,087	691,828
1902	1,010	12,400	12.27	33,313	729,421	762,734
1903 (*a*)	874	14,160	16.20	32,058	657,269	689,327

(*a*) Statistics of the United States Geological Survey.

Practically the entire imports of asbestos into this country come from Canada, which supplies at present the larger part of the world's consumption of this mineral. Outside of Canada there are deposits in northern Italy, Russia and Cape Colony that are of some importance in the trade.

Australia.—An asbestos property situated at Gundagai, New South Wales, was taken up in 1903, and contracts were made to supply large quantities in case the mineral should prove of satisfactory quality.

Canada.—The output of asbestos in the province of Quebec in 1903, as reported by J. Obalski, Inspector of Mines, was as follows: Crude asbestos, first-class, 930 short tons, valued at $117,847; crude, second-class, 2,354 tons, valued at $227,919; asbestos fiber, 9,650 tons, valued at $311,248; paper stock, 16,327 tons, valued at $259,956; asbestic, 9,906 tons, valued at $13,292; total, 39,167 tons, valued at $930,262. There were seven mines actively worked during the year, including the mines at Thetford, Black lake and Danville. The New England & Canadian Asbestos Company, which acquired control of the Beaver mine at Thetford, the Quebec and Montreal mine at Black lake and the Fraser mine at Broughton, went into liquidation and the properties mentioned reverted to their original owners. The New England Company mined from 400 to 500 tons of asbestos at Thetford. At Black lake the Union mine was worked during the whole year, and the Standard and Johnson mines during part of the year. At East Broughton the working of the Broughton asbestos mine was interrupted in October by fire, which completely destroyed the mill and machinery of that company. The construction of a new mill was begun at once, and will be placed in operation during the present year. At East Broughton the Walsh & Mulvena mine was reopened and the construction of a mill was begun, which will be started in the near future, the mine being operated under the name of the Quebec Asbestos Company. The mill comprises a building 75 by 40 ft., with two 'cyclones' and the usual accessories, power being supplied by boilers of 250 h. p. A new company known as the American Asbestos Company, Ltd., was formed to work the Murphy mine at Black lake. The company has begun the erection of a large mill, using the Sturtevant system of disintegrators, as well as a tramway, office, dwellings and other improvements. Electric power is to be used, supplemented by a steam plant which will be held in reserve. The Standard Asbestos Company has obtained good results with its new mill. At Danville the Asbestos & Asbestic Company completed the establishment of its new mill, which is one of the largest in existence. The equipment of the mill includes 2 single Blake crushers and 4 duplex Blake crushers, 4 cylindrical dryers, 4 'cyclones,' with 7 suction fans 45 in. diameter, 20 flat shaking screens and 6 revolving cylindrical screens. The crushing and grinding works are driven by Corliss tandem engines developing in the aggregate 850 h. p. The mill is electric lighted throughout. The mine operated by this company is equipped with eight steam hoisting drums of 20 h. p. each, working eight cable derricks, and an air compressor of a capacity of 20 drills. The derricks hoist 500 tons of rock in 10 hours, 400 tons of which go to the mill and 100 tons to the waste heap. About 40 tons of fiber are extracted from the 500 tons of rock. There are two principal excavations at the mine, the deepest of which is 170 ft. below the surface. The company owns a railway, five miles long, from the mine to Danville station, which it operates itself.

Italy.—The production of crude asbestos in 1902 amounted to 243 metric tons, valued at $22,930. Of manufactured products the output was 1,258 metric tons, valued at $292,714.

Russia.—The production of asbestos in 1900, the last year for which statistics are available, amounted to 3,845 metric tons. The productive mines are situated in the Urals. According to recent information asbestos deposits have been found in Siberia, near the Kutai river, and in Finland. A company has been formed to work the deposits in the latter country.

ASPHALTUM.

The total output of asphaltic products in the United States in 1903 was 101,255 short tons, valued at $1,005,446, against 98,880 short tons, valued at $746,341, in 1902. Included in these totals for each year is the output of residuum from the refining of petroleum that is sold and used as asphaltum.

PRODUCTION OF ASPHALTUM AND BITUMINOUS ROCK IN THE UNITED STATES. (IN TONS OF 2,000 LB.)

States.	1901.			1902.			1903. (a)		
	Tons.	Value.	Per Ton.	Tons.	Value.	Per Ton.	Tons.	Value.	Per Ton.
Bituminous sandstone:									
California	24,306	$77,661	$3.15	33,489	$79,809	$2.38	24,080	$69,862	$2.90
Kentucky	8,942	56,610	6.33	22,498	68,704	3.05	11,628	38,763	3.33
Indian Territory	1,000	4,330	4.33	e1,050	4,580	4.36	1,710	3,908	2.29
Arkansas	......	....	.....	800	4,000	5.00	1,215	5,468	4.50
Total	34,248	$138,601	$4.05	57,837	$157,093	$2.72	38,633	$118,001	$3.05
Asphaltic limestone:									
Indian Territory	2,970	15,375	5.20	1,130	4,020	3.56	2.520	8,800	3.49
Texas	4,000	18,000	4.50	*Nil.*	....	.....	*Nil.*	....	.....
Arkansas	......	....	.....	700	3,500	5.00	*Nil.*	....	.....
California	......	....	.....	29	262	9.03	*Nil.*	....	.....
Total	6,970	$33,375	$4.79	1,859	$7,782	$4.19	2,520	$8,800	$3.49
Asphaltum:									
California (g)	b19,988	316,559	15.83	f34,511	448,643	13.00	50,487	632,764	12.53
Indian Territory	98	1,000	10.20	376	3,219	8.56	877	15,442	17.61
Texas (g)	330	19,800	60.00	g245	3,992	16.29	2,158	30,550	14.16
Gilsonite:									
Utah	c1,500	46,000	30.67	4,052	125,612	31.00	5,619	188,357	33.52
Mastic:									
California	......	....	.....	......	....	.....	11	132	12.00
Kentucky	......	....	.....	......	....	.....	950	11,400	12.00

(a) Statistics of U. S. Geological Survey. (b) Includes 1,000 tons of liquid asphaltum valued at $49,850. (c) Estimated. (e) Includes production of Oklahoma Territory. (f) Includes 1,600 tons of liquid asphaltum, valued at $20,137. (g) Includes by-product asphaltum from refining crude oil.

The production of bituminous sandstone in 1903 was 38,633 short tons, valued at $118,001, as compared with 57,837 short tons, valued at $157,093, in 1902. There was a large falling off in the output of both California and Kentucky, which are the chief sources of bituminous sandstone in this country. The quantity of bituminous limestone produced in 1903 was 2,520 short tons, valued at $8,800, against 1,859 short tons, valued at $7,782, in 1902. The entire supply in 1903 came from Indian Territory, the quarries in Arkansas and California being inoperative. The production of hard asphaltum in 1903 was 53,522 short tons, valued at $678,756, against 35,132 short tons, valued at $455,854, in 1902. In the totals for 1903 are included 46,187 tons of by-product asphaltum from oil refining, valued at $522,164, and 58 tons of liquid asphaltum, valued at $1,150. The production of gilsonite in Utah in 1903 was 5,619 short tons, valued at $188,357, against 4,052 short tons, valued at $125,612, in 1902. During 1903 there was also produced 961 short tons of mastic, valued at $11,532.

During 1903 the National Asphalt Company and the Asphalt Company of America, which had gone into receivership, were reorganized under the title of the General Asphalt Company with a capitalization of about $30,000,000. The first report of the new company for the year ending May 30, 1904, showed net profits of $860,226. The quantity of asphalt mined was 204,340 tons, of which 181,076 tons came from the Trinidad and 23,264 tons from the Bermudez deposits. The product of refined asphalt was 99,564 tons.

Arkansas.—It is reported that the asphalt lands of Wolf Creek, Pike county, have been leased for the purpose of working.

California.—The by-product asphalt industry has become of great importance, the quantity recovered in 1903 largely exceeding the output of natural rock. A full review of the industry by F. H. Minard will be found elsewhere in this chapter.

Indian Territory.—(By W. R. Crane.)—The discoveries of asphalt in the Indian Territory[1] have been confined almost wholly to the Chickasaw nation, the principal deposits being at Ravia, Dougherty and Tar Springs. At Ravia and Dougherty the asphalt occurs as asphaltic sand and bituminous limestone, while at Tar Springs the deposits take the form of sand and sandstone. Grahamite occurs at several localities near Tar Springs. The asphalt deposits at Tar Springs are found beneath a thin sandstone stratum and consists in general of uncemented sandstone impregnated with asphalt and oil with a thickness of 6 or 7 ft. Besides the surface deposits now worked, the existence of deeper beds has been proved by drilling. One prospect hole drilled to a depth of 600 ft. showed 150 ft. of asphalt deposits separated by thin strata of clay and shale. Working tests on the asphaltic sands yielded from 10 to 14 per cent asphaltum in the crude material, besides 20 to 30 per cent heavy oils, probably largely petrolene, giving a total hydrocarbon content of 30 to 44 per cent.

The asphalt is obtained by open-cut work, or stripping, which consists of the following operations: Breaking and removing the sandstone capping; loosening the asphaltic sands; excavating and hauling to the refinery. The first operation is accomplished by drilling and blasting. Two-inch holes are drilled to a depth of three feet, and a charge of dynamite is introduced (in the case of dry holes, black powder), and fired electrically. The blasts cause the sandstone capping to loosen up, so that it can be readily removed. The exposed bed of asphalt is then plowed and the material drawn out by wheel scrapers.

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1 The Engineering and Mining Journal, 1903, Vol. LXXVI, p. 926.

In refining, the crude asphalt is run through a disintegrator and hoisted to the top of the building, where it is fed into separating tanks. There are three sets of tanks in a series: First, separators (one); second, accumulators (two), and, third, reducers (two). The separators are really spitzlutten, which disintegrate the sand in water heated to 180° F. From the separators the over-product passes to the accumulators which are heated by steam coils. Here practically all of the water and a large part of the oil are driven off; and the asphalt, with the remaining oil, passes to the reducers, where it is brought to the proper consistency by the direct application of heat to the bottom of the tanks. The reducers discharge into the barreling room, and the product after straining is filled into barrels and cans for the market.

The plant at Tar Springs, which was destroyed by fire in August, 1903, had a daily capacity of 10 tons finished product, or 100 tons of crude sand. The costs at this plant were about as follows: Excavating and handling asphalt sand, $0.07 per cu. yd.; fuel, $2.50 per ton asphaltum; territorial charges, $0.60 per ton; labor, $2.21 per ton; transportation, $2.00 per ton; barrels, $1.60 per ton. The average net cost of producing refined asphaltum was about $15 per ton.

THE WORLD'S PRODUCTION OF ASPHALTUM AND ASPHALTIC ROCK. (IN METRIC TONS.)

Year.	Aust'a	France	Germ'y	Hung'y	Italy.		Russia	Spain.		Trinidad. (*b*)	United States.		Venezuela. (Bermudez)
	Asph. Rock.	Asph. Limestone. (*a*)	Asphaltum.	Asphaltum.	Asphaltum. (*c*)	Asph. Rock.	Asph.	Asph.	Asph. Rock.		Asphaltum.	Asphaltic Rock	
1897	300	30,946	61,645	3,057	18,644	55,339	22,222	1,878	1,656	133,310	24,854	45,233	11,528
1898	643	36,000	67,649	3,125	17,813	93,750	12,018	2,354	2,354	108,792	23,306	57,728	*Nil.*
1899	2,635	39,000	74,770	3,060	41,732	81,987	23,081	2,646	2,542	144,340	13,662	50,061	12,014
1900	887	34,093	89,685	2,900	33,127	101,738	25,090	2,331	4,193	161,299	8,326	41,029	17,981
1901	541	29,815	90,193	2,878	31,814	104,111	(*d*)	4,182	3,956	167,253	19,882	37,393	22,115
1902	901	34,000	88,374	2,773	33,684	64,245	(*d*)	6,064	6,301	167,253	36,923	35,072	10,770
1903	1,277	(*d*)	87,454	(*d*)	(*d*)	(*d*)	(*d*)	4,372	6,277	196,883	48,555	37,334	14,567

(*a*) France produces a large amount of bituminous shales, used for distilling oil, which is not included in these statistics. (*b*) Exports (crude equivalent) reported by The New Trinidad Lake Asphalt Co. (*c*) Including mastic and bitumen. (*d*) Not yet reported.

NOTE.—There is a considerable production of asphaltic stone in Switzerland of which no account is taken in the above table, the Swiss Government not publishing any mineral statistics. The production of asphalt in Cuba and of manjak in Barbados are not included in the statistics given.

Barbados.—The exports of manjak, a form of glance pitch, in 1903 were 651 tons, as compared with 868 tons in 1902. There were nine mines in operation during 1902, of which three were worked by the Barbados Manjak Mines, Ltd. Manjak is used in the manufacture of varnish and electric insulating materials.

Colombia.—A deposit of asphalt situated near Chaparral, Tolima, is being worked by the Home Land & Mining Company, of New York. The asphalt contains about 99.5 per cent bitumen and is adapted to the manufacture of paints and varnishes. It is shipped to the United States and Germany, where it commands about $65 per short ton. The present output amounts to 2,000 tons per annum.

Cuba.—The asphalt resources of Cuba were described by H. C. Brown in THE MINERAL INDUSTRY, Vol. XI. Most of the product, which is of growing importance, is shipped to the United States, the shipments for the last two years being as follows: 1902, 4,888 long tons, $19,162; 1903, 7,252 long tons, $28,497.

France.—Asphaltic limestone is mined in the departments of Ain, Gard, Puy-de-Dôme and Haute-Savoie, the output in 1902 being 34,000 metric tons. The material is converted into mastic, paving blocks and ground asphalt. France also produces a large quantity of bituminous slate, but it is distilled for oil and cannot be classed as an asphaltic material.

Italy.—The product of asphaltic rock in 1902 was 64,245 metric tons, valued at $151,829, while of refined products, including ground asphalt, mastic and bitumen, the output was 33,684 tons, valued at $193,324. The asphalt deposits are situated at Ragusa and Vizzini, on the island of Sicily, and at San Valentino, province of Chieti. The Sicilian product is shipped in the form of asphaltic rock and ground asphaltum through the ports of Syracuse and Mazzarellis. The product of San Valentino is mostly converted at local works into ground asphalt, mastic and bitumen. The latter deposits are said to be very extensive.

EXPORTS OF LAND ASPHALT FROM TRINIDAD. (*a*) (IN TONS OF 2,240 LB.)

Year.	To United States.			To Europe.			To Other Countries.			Grand Total of Exports in Crude Equivalent.
	Crude.	Epuré.	Total Equivalent in Crude.	Crude.	Epuré.	Total Equivalent in Crude.	Crude.	Epuré.	Total Equivalent in Crude.	
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
1898.....	18,160	*Nil.*	18,160	700	258	1,087	404	312	872	20,119
1899.....	25,613	345	26,130	275	280	695	....	100	150	26,975
1900.....	34,796	(*b*)	34,796	251	(*b*)	251	197	(*b*)	197	35,244
1901.....	31,767	11	31,767	1,704	(*b*)	1,704	1,446	(*b*)	1,446	34,917
1902.....	25,003	100	25,153	200	....	200	15	50	90	25,443
1903.....	18,478	...	18,478	2,258	628	3,200	1,347	224	1,686	25,346

EXPORTS OF PITCH-LAKE ASPHALT FROM TRINIDAD. (*a*) (IN TONS OF 2,240 LB.)

Year.	To United States.			To Europe.			To Other Countries.			Grand Total of Exports in Crude Equivalent.
	Crude.	Dried.	Total Equivalent in Crude.	Crude.	Epuré and Dried.	Total Equivalent in Crude.	Crude.	Epuré and Dried.	Total Equivalent in Crude.	
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
1898.....	46,089	1,692	48,424	15,703	13,228	35,537	693	1,646	2,999	86,960
1899.....	70,111	480	70,777	21,337	13,749	41,956	....	1,699	2,359	115,092
1900.....	67,758	3,180	70,938	23,386	16,114	47,352	1,422	2,420	4,453	122,743
1901.....	80,449	*Nil.*	80,449	31,213	15,815	54,761	....	586	844	136,054
1902.....	101,876	2,211	104,956	17,711	10,509	33,474	....	536	746	139,176
1903.....	118,661	3,536	123,582	27,025	13,921	40,946	1,000	3	1,004	165,532

(*a*) The exports prior to 1898 will be found in THE MINERAL INDUSTRY, Vol. VIII. (*b*) Included in the shipments of crude.

Trinidad and Tobago.—The exports of asphalt from the island of Trinidad, as reported by the New Trinidad Lake Asphalt Company, Ltd., are shown in the tables above. Most of the asphalt exported is taken from Pitch lake, which is held by the company under a lease that does not expire until 1930. The lake contains no liquid asphalt, but this variety is found widely distributed in other parts of the island. Glance pitch, used for electric insulations and varnishes, also occurs. The total quantity of asphalt taken from Pitch lake exceeds 2,000,000 tons, but as there is a constant flow of material from subterranean sources the removal of this enormous quantity has made little impression on the supply.

Venezuela.—The exports of asphaltum from Maracaibo in 1903, according to the British consular agency, amounted to 14,338 long tons, valued at $286,-700. The Venezuelan government has given notification that hereafter asphalt locations cannot be denounced by private individuals. The ownership of the Felicidad mines, which has been in dispute for the past five years, was decided in favor of the New York & Bermudez Company. This company claims the exclusive right to work the deposits of Bermudez lake. It is reported that the output from this source in 1903 was 23,264 tons, which is in excess of the exports as given above.

Ozokerite.

The world's consumption of ozokerite continues to be supplied by the mines in Austrian Galicia. The output in 1902 amounted to 3,275 metric tons and came from the following districts: Boryslaw, 2,565 tons; Dzwiniacz-Starunia, 650 tons; Truskawiec, 60 tons. The average value of the material was about $220 per metric ton. The exports in 1903 were 2,258 metric tons, valued at $722,432. A description of the occurrence, uses and technology of ozokerite will be found in previous volumes of The Mineral Industry.

The California Asphaltum Industry.

BY F. H. MINARD.

The manufacture of asphaltum from crude oil in California is a new industry, and, although there are many plants in the different fields, the production is erratic, rising and falling according to the varying conditions of the asphaltum market. There is no stability either in the price of the raw material or in the price of the finished product.

Up to two years ago the asphaltum of the country was furnished by the company owning the Trinidad deposits, and shortly after the formation of the Asphalt Trust the market and the contracts for paving in all the large cities were practically in its control. During this period the asphaltum made from California oil began to find its way to the eastern markets, and shortly thereafter the Trust went into the hands of a receiver. These two facts depressed prices, and California asphaltum sold as low as $18 and as high as $24 per ton, laid down in New York. In the cities in which previous contracts were not in force the California product found a market, and last year between 25,000 and 30,000 tons of it were shipped east. The struggle between the eastern and western manufacturers often lowered the prices to a point where the manufacture of asphaltum from the crude oil became unprofitable. The producers have now practically established a price of $12 per ton for the California and western markets. This is for the general grade "D," which is used for paving and roofing.

Production of Asphaltum from Oil.—The following are the plants located in the different fields, the capacity of each in crude oil per month, the number of men employed and the number of tons of asphaltum produced per month:

	Oil, Bbl.	No. Men.	Tons.
Sunset Field:			
Jewet & Blodgett	4,000	7	300
Navajo	3,000	6	225
Bakersfield Field:			
Pacific Refining Company	18,000	14	1,350
Los Angeles Field:			
Densmore-Stabler	17,000	14	1,050
Southern Refining	10,000	29	750
Hercules	8,000	12	600
New Franklin	3,266	12	600
Union Consolidated Company	4,000	14	300
Cooms	3,600	10	195

Although the above plants have the tabulated capacities when in full operation, yet none of them runs at full capacity.

There is one small refinery in San Francisco and two small ones in the Kern River oil district, just out of Bakersfield, but they are of little importance, and the above plants produce 90 per cent of the asphaltum manufactured in California.

Process of Manufacture.—The process of making asphaltum from crude oil consists in distilling over the volatile oils at a high temperature and drawing off the residual heavy oils with the carbon as asphaltum. The crude oil is either hauled in tank cars to the refineries, or, in several instances where the refining companies own their own wells and have their plants located in the vicinity, the oil is pumped direct from the wells to the storage tanks. It is then pumped into stills made of heavy boiler iron, where the distillation takes place. These stills vary in capacity from 100 barrels to as high as 600 barrels, but the most successful size now in use is 300 barrels. The stills are never filled to within 85 per cent or 90 per cent of their capacity, as the oil expands upon heating. Through the stills, on each side at the bottom, run perforated pipes, through which, during the process, a constant current of air is forced, which keeps the oil stirred and forces the distillates, which are heavier than air, over into the condensers. The air method is a patent process, and is claimed by the users to give the oil an oxidizing distillation that conforms to the natural distillation in nature, thereby benefiting the asphaltum.

The heating is done either by crude oil or by fuel distillate, the latter being made in the process of distillation, and this is done at a temperature of 650°. This heat has to be obtained in order to drive over the last heavy distillates that come over from the asphaltum, and this point is determined by taking the specific gravity, which must be as low as 22° Baumé. The distillates pass from the still, or stills, into condensers, which are large wooden tanks filled with 2-in. pipe, and cooled by water that is constantly pumped in. With the condensers it takes about 1,600 ft. of pipe to condense for a still of 300 barrels capacity, and requires 200,000 gal. of water per 24 hours to keep the oil from reaching over a temperature of 200 degrees. The distillates then run into the tail house, where the gravities are taken at intervals of every hour, and in this manner it is known exactly what the still is doing, and the distillates of different gravity are turned into separate tanks, depending on the purpose for which they are to be used. These distillates are used as engine distillates, fuel distillates and lubricating oils. When the last distillates come off, the asphaltum is drawn from the bottom of the stills into coolers, allowed to remain there 24 to 48 hours, and is then ready for barreling and shipping. It takes from 33 to 36 hours to make a distillation, or 'run,' and 20 runs are made per month. The cooling is the only dangerous point in the process; the asphaltum is very hot, still giving off gases that explode spontaneously when mixed with a certain percentage of air, thus causing destructive fires, and nearly all the plants have suffered from such fires during some period. This is a general outline of the process, and, of course, each plant and stillman has his own method of manipulation, which is guarded more or less carefully from the inquirer.

The cost of asphaltum plants varies from $20,000 to as high as $75,000, depending, of course, upon the capacity of the plant, and whether the refiners manufacture its by-products into illuminating and lubricating oils.

This industry is a very recent one, and even California has a great deal to learn in regard to asphaltum refining, especially in the selection of oils, and in the mechanical manipulation of the distilling process. As no asphaltum was ever made from eastern oils, it can readily be understood why eastern experience has very little application to the California refining methods.

Costs.—It is difficult to give any satisfactory statement of the costs of refining California crude oils for asphaltum, owing to the fact that so many variables enter into its manufacture. Most plants purchase the crude oils for refining, although some of the refineries own their own wells, while others lease wells, paying a royalty. Some plants are located close to the wells and can pump their oil direct, while others are some miles distant, and have to haul by tank cars. In two or three instances the distillates are separated, according to their specific gravities, and some sold for fuel when there is a close market, and the rest made into different grades of lubricating oils. But other refineries do not separate them, and they are all tanked as fuel distillates, burning what is needed, selling as much as possible, at prices varying from

20c. to 30c. per bbl., and, in one instance, the distillates are thrown away and nothing is saved but the asphaltum.

The California oils carry all the way from 25 to 55 per cent of asphaltum, the Los Angeles field having about 25 to 30 per cent, the Sunset as high as 55 per cent, and an average of 45 per cent, while the Kern River field contains about 35 per cent. Some oils contain more water than others, which interferes greatly with the distillation, causing the oil to foam, and the first heat has to be slow until the water is evaporated. Generally there is 3 to 4 per cent of waste in refining, but this percentage varies, and sometimes attains as high as 12 per cent. Some of the refineries make a specialty of lubricating oils and asphaltum, some of asphaltum and fuel and engine distillates; others of asphaltum alone. The cost of crude oil to the different refining plants varies greatly; for those refineries near their own wells it is estimated that oil costs them 11½c. per bbl., including pumping, interest, and returning the investment on the land, the life of the well being taken at 15 years. Those buying oil pay up to 50c. per bbl., delivered at the plant, the price depending on the quality of the oil, that running the highest in asphaltum products being the cheapest. The price of oil in California is gradually rising, on account of the large quantities used as fuel by the railroads.

The above facts clearly show what are the varying factors in the making of asphaltum from crude oil, and it will be readily understood how many varying combinations can be made of these factors, all of which have a direct influence on the cost of production.

But the greatest influence in the manufacture of crude oil products in California is going to be exercised by the Standard Oil Company, who are just completing their refinery at Point Richmond, near Oakland. This plant is certainly a modern refinery in every detail. It has a capacity of 2,400 bbl. per day, and will make all the petroleum products. It is claimed, however, that no asphaltum will be made, the distillation being carried out until coke is obtained. The pipe line to the Kern River oil field and refinery represents an expenditure of several million dollars, and the company will inevitably control the markets, as it can produce asphaltum whenever it desires at a much cheaper cost than the small plants.

Character of the Product.—Asphaltum made from crude oil is perfectly homogeneous and runs as high as 95 per cent bitumen, but there is no question that the high heat to which it is subjected injures the asphaltum, for in heating to 650 degrees some of the hydro-carbons in the asphaltum are decomposed, and, consequently, are not as stable, and make a less durable pavement. It has been suggested that the distillation be carried on at a low temperature and allowed to extend over a longer time, but experiments have shown that at a low temperature small particles of pure carbon separate out in the asphaltum, which is more injurious than the unstable compounds of the high heat. Pavements laid with crude oil asphaltum have been as patchy and as unsatisfactory as those made of the natural, but without doubt many of the poor results with the former have been due to the carelessness in its manufacture, especially allowing the heat to get above 650 degrees, which is very easy to do, as none of the plants have the proper apparatus for measuring temperature. Another cause is the careless mixing of the asphaltum with the sand and gravel in making the asphalt.

The markets have been prejudiced in favor of Trinidad asphaltum for many years, and it has been named in all contracts by the large cities, but the California product is getting into the eastern market, and has given good results in many instances. The real and important difference in the two grades is the cost per ton laid down at the points of consumption, with the advantage on the side of the Trinidad product. However, with improvements in the plants, more care in manufacture and the establishment of a stable market for the refined asphaltum and its by-products, thus cheapening the cost of production, there is no reason why asphaltum manufactured from crude oil cannot share the market with that made from the natural deposits of Trinidad Island.

The Natural Asphaltum Deposits.—Natural asphaltum, bitumen beds, or 'rock asphalt' has only been found in large quantities in the southern oil fields of California, and the largest and by far the most important deposits are located in Santa Barbara county. Asphaltum, as found existing in the natural form, is a hard, brittle substance, the purest of which chips like glass in cold weather. The impure grades break like ordinary rock, and contain varying percentages of impurities in the form of shale, gravel and sand. There are different degrees of purity of natural asphaltum in the same deposit. The natural substance may carry as high as 92 per cent bitumen, but this is rare. There is a small deposit near San José, which is out of the producing oil fields, containing very pure asphaltum mixed with a clean, white sand and gravel, and is ready for market for paving purposes when it is extracted; but the bed is small, and the percentage of asphaltum is not at all regular; consequently it makes a patchy pavement and is not now used to any extent. Probably the purest deposit in the entire State is a small bed in the McKittrick field, from which the asphaltum is mined and sent direct to eastern markets, and is used entirely for making paints and varnishes; but only small shipments are made.

The natural asphaltum of California differs in its mode of occurrence from that of Trinidad Island; the latter is found in a lake or basin depression, and is mined from this basin, which is constantly renewed from below. Its source is probably from petroleum that finds its way to the surface, and undergoes natural distillation by oxidation, thus forming a constant supply in the basin. Trinidad asphaltum contains about 39 per cent bitumen. These deposits are easily worked, and it is not expensive to manufacture refined asphaltum from such a product.

The California deposits are somewhat different, as they are not renewed, have a hard texture, and when worked long enough are exhausted. Beds, or strata of shale, sandstone and sand have been saturated with petroleum and have been distilled by natural processes until they have become solid asphaltum beds, containing impurities in the form of shales, sandstone and sand; consequently, it is well understood that no average content of bitumen can be given to them, as the beds are not homogeneous, and, as previously stated, run from almost pure streaks down to a very low percentage of asphaltum. The deposits are hard and expensive to mine on account of the toughness of the material. In some cases the deposits are so hard that after the asphaltum has been driven out by distillation the remaining shale is hard and can be broken only by a blow. Some small beds of asphaltum are found which are derived from the oxidation of petroleum that runs out on the surface, and in its course gathers up large quantities of sand, gravel, mud and vegetable matter, which makes them very impure and of no value commercially. Asphaltum existing in natural deposits must be refined and manufactured into a proper grade, to be of any practical value.

Manufacture of Asphaltum from Natural Deposits.—Several attempts have been made to manufacture asphaltum from the natural asphaltum deposits of California; the most extensive plant for this purpose was erected by the Alcatraz Paving Company, which owns very large beds of bituminous sand in the Sisquoc hills. A pipe line was laid from the deposits to the coast at Alcatraz Landing, 28 miles distant. The lighter distillates from crude California petroleum were prepared at the landing, and pumped through the pipe line to the Sisquoc hills, where these distillates were used for extracting the bituminous sands. The bitumen, in a state of solution, was then run to the coast by the pipe line, and the oil again recovered, leaving a residue of solid bitumen. Several grades of asphaltum were made, ranging from the "F" grade, or "flux," to a hard "A" grade, and these products were obtained by stopping the process at various stages in the distillation. The Alcatraz Company expended something like $700,000, and made an excellent grade of asphaltum, claiming for it many advantages over that made from crude oil. The low temperature at which it was made was one argument in its favor, and undoubtedly a just one, and it had all the good qualities of a natural asphaltum. However, the great disadvantage in cost could not be overcome. This was too expensive a method, and their asphaltum could not compete with that made from crude oil, although it brought a higher price and was a better grade; nor could it compete with Trinidad asphaltum. Consequently some time after this plant was in operation the company began to buy asphaltum manufactured from crude oil, in order to fulfill their contracts, and soon afterward they shut down their plant and gradually adapted it to making asphaltum from crude oil. Later the Alcatraz Company went into the Asphalt Trust, which is now in the hands of a receiver, and the plant is now shut down.

The Pacific Oil & Asphalt Company of San Francisco made long and extensive experiments in the manufacture of asphaltum from the natural deposits of Santa Barbara county, and, although it did not erect a large plant for its manufacture, it expended $30,000 in a small but well equipped plant at San Francisco for thorough investigation. The results obtained were very gratifying, so far as the character of the asphaltum was concerned. The natural asphaltum, or "rock asphalt," was brought to the plant and sorted up to a product containing 40 per cent bitumen, and this was ground to pass a 30-mesh screen, which thoroughly mixed it. The impurities in the form of finely ground shale and sandstone took the place of the lime-carbonate and sand, which are mixed with all asphaltum paving material to-day. This finely ground product was then mixed with flux and heated to the low temperature of 250 degrees, just hot enough for it to become thoroughly homogeneous, and no distillation of any kind was made. It was then run off into barrels, ready for the market. The quality of asphaltum was excellent, and was acknowledged by many on the coast to be the best product on the market; it was not only made from natural asphaltum, but it was made without any distilling, thus avoiding high temperatures, and it had been mixed in the process of its manufacture with a percentage of sand that insured a very homogeneous product. But the Pacific company met with the same difficulty as the Alcatraz company, and the asphaltum was so expensive to manufacture that even with its superior quality it could not compete with the cheaper asphaltum made from crude oil and that from Trinidad. Although this high cost was reached in a small plant, yet it was estimated that its manufacture on a large scale in an expensive plant, located at the natural beds, and by a company owning the deposits, could not sufficiently reduce the cost, and as it would require half a million dollars to build plants and establish a market for the product, the gentlemen fostering the enterprise did not think the industry attractive.

The above are the only serious and important attempts that have been made in California to manufacture asphaltum from the natural deposits, and the companies manufacturing such, although each of them used different methods, found it impossible to make asphaltum from the natural deposits and compete with that made from other sources, although they made a better product. So there is no asphaltum made from the natural deposits of California. In two cases tried the cost of production has proved to be prohibitive, and all the asphaltum that is now used on the coast is made from crude oil.

BARYTES.

The production of barytes in the United States during 1903 was 50,397 short tons, valued at $152,150, against 58,149 short tons, valued at $186,713, in 1902. Missouri yielded the largest output, followed by Tennessee, North Carolina and Virginia in the order mentioned.

The following tables give the production, imports and exports of barytes in the United States from 1899 to 1903, and the world's output for the years 1898 to 1902:

PRODUCTION, IMPORTS, AND CONSUMPTION OF BARYTES IN THE UNITED STATES.

(In tons of 2,000 lb.)

Year.	Production.			Imports.			Consumption.	
	Quantity.	Value Per Ton.	Value.	Quantity.	Value Per Ton.	Value.	Quantity.	Value.
1899	32,636	$4.20	$137,071	4,312	$6.59	$28,407	36,948	$165,478
1900	41,466	3.90	161,717	5,625	5.77	32,461	47,091	194,178
1901	49,070	3.22	157,844	5,604	7.04	39,442	54,674	197,286
1902	58,149	3.21	186,713	7,836	6.59	51,711	65,985	238,424
1903(a)	50,397	3.02	152,150	12,821	5.58	71,503	63,218	223,653

(a) Statistics of the United States Geological Survey.

PRODUCTION OF BARYTES IN THE PRINCIPAL COUNTRIES. (a) (IN METRIC TONS.)

Year.	Belgium.	Canada.	France.	Germany.				United Kingdom.	United States.
				Baden.	Bavaria.	Prussia (b)	Saxony.		
1898	21,700	971	2,763	1,100	4,339	48,082	478	21,514	28,247
1899	25,900	653	4,058	2,430	6.214	52,920	216	25,059	29,607
1900	38,800	1,207	3,035	2,970	10,515	60,099	516	29,937	37,618
1901	22,800	592	4,145	3,991	8,711	75,534	410	28,054	44,516
1902	33,000	995	4,323	(c)	8,034	90,177	72	23,986	52,661

(a) From official reports of the respective countries, except the statistics of the United States. (b) Output of the mining districts of Clausthal and Bonn. (c) Statistics not yet available.

Market.—The consumption of barytes in 1903 was good, and prices held steady throughout the year. Crude barytes at the mines brought from $3 to $5 per ton. New York quotations for large lots were: Crude, No. 1 domestic, $9@$9.50; No. 2 domestic, $8; No. 3 domestic, $7@$7.75. Foreign barytes, gray in color, brought $13.50@$14.50, and white $17@$18. Blanc fixe (artificial barium sulphate) was quoted at 1⅞c.@2c. per lb.

Kentucky.—This State produced a small quantity of barytes from a deposit near Fredonia, Caldwell county. The mines are owned by the Marion Zinc Company.

Missouri.—Barytes mining is carried on with more or less activity in Washington, St. Francois, Cole, Miller and Crawford counties. One of the largest producers is the American Lead & Baryta Company, which operates a plant of 25-tons daily capacity at Mineral Point, Washington county. The equipment comprises a crusher, washers, slip mills, settling and bleaching tanks, driers, pulverizers, etc. The barytes is obtained from shallow deposits in the vicinity. Among other producers in Washington county are the National Barium & Lead Company and the Washington Land & Mining Company, while there are numerous small operators who sell their product to one of the larger companies or to shipping firms. The greater part of the mineral obtained in this section is marketed as No. 1 grade and used for paint purposes. The prices obtained for No. 1 barytes in 1903 ranged from $4.25 to $5 per ton f.o.b. car.

New York.—The discovery of a deposit of barytes was reported near Richville, St. Lawrence county.

Tennessee.—There was marked activity in barytes mining during 1903, and the output increased from 3,255 short tons in the previous year to 14,684 short tons. The production was made by sixteen mines, situated in Monroe, Loudon, Cocke, McMinn and Sevier counties. J. T. Williams & Sons, of Bristol, control the entire industry, with the exception of a small mine at Kodak, Sevier county. The mineral is shipped to Bristol, where there is a plant for grinding and for manufacturing barium salts, blanc fixe and other products.

BAUXITE.

The production of bauxite in the United States in 1903 amounted to 48,087 long tons, valued at $171,306, showing an increase of about 60 per cent over the total for the previous year, which was 29,222 long tons, valued at $128,206. The year witnessed a further gain in the production of Arkansas, which now greatly exceeds the combined output of Georgia and Alabama.

PRODUCTION, IMPORTS, EXPORTS AND CONSUMPTION OF BAUXITE IN THE UNITED STATES.

Year.	Production.			Imports.		Exports.		Consumption.	
	Long tons	Value.	Per ton.	Long tons.	Value.	Long tons.	Value.	Long tons.	Value.
1899...	36,813	$101,235	$2.75	6,666	$23,768	2,030	$4,567	41,449	$120,436
1900...	23,445	85,922	3.66	8,656	32,967	1,000	3,000	31,101	115,889
1901*a*..	18,905	97,914	4.23	18,313	66,107	1,000	3,000	36,218	144,021
1902...	29,222	128,206	4.39	15,790	54,410	*Nil.*	.....	43,112	175,875
1903*a*..	48,087	171,306	3.56	14,889	49,684	*Nil.*	.....	62,976	220,990

(*a*) Statistics of the United States Geological Survey.

Although the manufacture of aluminum is one of the principal applications for bauxite in this country, a larger proportion, estimated at nearly, if not fully, half of the total supply, is consumed in the preparation of alum and other aluminum salts. In the last year, also, shipments of Arkansas bauxite have been made to Niagara Falls, where it is used in making artificial corundum for abrasive purposes. It is said that the quantity thus consumed amounts to over 5,000 tons annually. At present the uses of bauxite in the United States are limited to the three industries mentioned, but a fourth promises to become prominent. In Europe the refractory qualities of bauxite have been recognized, and it is extensively employed for lining furnaces where a basic flux is needed. Owing to the cheapness and superior qualities it is able to compete favorably with magnesite and other refractory substances. So far its use for furnace linings in this country has not progressed beyond the experimental stage.

An event of importance to the industry has been the completion of the Pittsburg Reduction Company's plant for calcining and preparing the crude bauxite at Bauxite, Ark., described in THE MINERAL INDUSTRY, Vol. XI. The company has also started its new refining plant at East St. Louis, where it will treat the material formerly shipped to New Kensington, Pa. The refining process consists in removing the iron oxide and silica, and the preparation of pure aluminum oxide.

According to W. F. Berger[1] the bauxite deposits of Arkansas are associated with eleolite syenite, which occurs in Pulaski and Saline counties. The mineral is not true bauxite, namely Al_2O_3, $2H_2O$, but gibbsite, which is the trihydrate of alumina, Al_2O_3, $3H_2O$. The deposits are found along a series of low ridges, 20 miles long and a mile wide. There are two varieties of this mineral, of which one has been formed by the alteration of eleolite in place, and the other by solution of the alumina in the feldspar and eleolite and precipitation in the form of hydrate. The former variety preserves the structure of the syenite and occurs in beds averaging 15 ft. thick covered by a thin stratum of soil. The second variety is found in bedded deposits, averaging 20 ft. thick that extend outward from the ridges for the distance of a mile or more. Most of the mining at present is done along the sloping hillsides, where artificial drainage is not necessary. The first step in mining consists in opening a face of ore. The soil is then stripped, heavy charges of blasting powder are put in drill-holes 15 ft. deep, and the face is broken down and loosened. After blasting, the material is loaded into carts or train cars. Owing to the presence of ribbons and segregations of iron, a rough sorting is usually necessary, the waste being thrown back into workings.

PRODUCTION OF BAUXITE IN THE PRINCIPAL COUNTRIES OF THE WORLD.
(IN METRIC TONS.)

Country.	1896.	1897.	1898.	1899.	1900.	1901.	1902.
France	33,820	41,740	36,723	48,215	58,530	76,620	96,900
United Kingdom	7,365	13,449	12,600	8,137	5,873	10,357	9,192
United States	17,370	20,919	27,220	37,402	23,556	19,207	29,690
Total	58,555	76,108	76,543	93,754	87,959	106,184	135,782

1 The Engineering and Mining Journal, April 14, 1904.

BROMINE.

The production of bromine in the United States in 1903, including the quantity of bromine contained in potassium bromide, was 597,000 lb. against 513,913 lb. in 1902. The market during 1903 was very erratic; the prices in the early months ranged around 25c. per lb., but rose to as high as 40c. in July and August and declined to 30c. in the latter part of the year. The average for the entire year may be taken at 28.5c. per lb. As heretofore the production in the world continues to be controlled by the associated American producers and the Leopoldshall-Stassfurt convention of Germany.

PRODUCTION OF BROMINE IN THE UNITED STATES.

Year.	Michigan.	Ohio.	Pennsylvania.	West Virginia.	Total.	Metric Tons.	Value.	
							Total.	Per Pound.
	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.			
1899	(a)138,272	82,368	111,150	101,213	433,003	196	$125,571	29c.
1900	(a)210,400	91,182	105,592	114,270	521,444	237	140,790	27c.
1901	(a)217,995	125,467	101,595	106,986	(b)552,043	250	154,572	28c.
1902	(a)226,452	100,491	93,595	93,375	513,913	233	128,472	25c.
1903	(a)320,000	180,000	(c)	97,000	597,000	271	170,145	285c.

(a) Including the bromine equivalent of the product recovered as potassium bromide. (b) Of the total production, 348,913 pounds were in the liquid form. (c) Production included under Ohio.

The producers of bromine in the United States are as follows: The Dow Chemical Co., Midland, Mich.; Wayne Chemical Co., Saginaw, Mich.; St. Louis Chemical Co., St. Louis, Mich.; Saginaw Salt Co., St. Charles, Mich.; John A. Beck & Co., Allegheny, Pa.; J. L. Dickinson & Co., Malden, W. Va.; Hope Salt & Coal Co., Mason, W. Va.; Liverpool Salt & Coal Co., Hartford, W. Va.; Hartford City Salt Co., Hartford, W. Va.; Syracuse Coal & Salt Co., Syracuse, O.; Coal Ridge Salt Co., Pomeroy, O.; Buckeye Salt Co., Pomeroy, O.; Excelsior Salt Works, Pomeroy, O. The United Salt Co., Cleveland, O.; the Independent Salt Co., Saginaw, Mich., and the Myers Bros. Drug Co., St. Louis, Mo., who have been producers in previous years, are no longer engaged in the trade.

A new development in the bromine industry is the establishment of salt blocks near St. Charles, southwest of Saginaw, to obtain salt from the Marshall brine by utilizing waste coal. Bromine is reported to be extracted from the bittern to the extent of 100 lb. per day. The Dow Chemical Company has started a new plant at Mt. Pleasant and has sunk four wells which reach the Marshall sandstone at a depth of from 1,405 to 1,565 ft.

CARBORUNDUM.

The production of carborundum by the sole manufacturer in 1903 was 4,760,000 lb., against 3,741,500 lb. in 1902. The Carborundum Company is enlarging its plant at Niagara Falls, and the added capacity will enable it to turn out about 8,000,000 lb. per year. At present the works contain fifteen 1,000-h. p. furnaces, each furnace yielding 8,500 lb. in a run of 36 hours. A total of 3,000 h. p. is required to maintain this output. The new furnaces are designed for 3,000 h. p. The carborundum crystals are graded for market in 20 sizes, from No. 8, passing through an 8-mesh screen, to No. 220, passing through a 220-mesh screen. The three grades of "carborundum flour" are obtained by washing the finest crystals. By stirring the fine powder in water and allowing it to settle one, two, four or more minutes, and then decanting the water and allowing the suspended material to settle, minute powders called "hand washed" one, two, four, etc., are obtained.

PRODUCTION OF CARBORUNDUM IN THE UNITED STATES.

Year.	Quantity.	Value.
	Pounds.	
1900	1,741,245	$216,090
1901	3,838,175	345,435
1902	3,741,500	374,150
1903	4,760,000	476,000

CEMENT.

The total production of cement in the United States during 1903 amounted to 29,899,140 bbl., valued at $31,931,341, as compared with the total output of 25,753,504 bbl., valued at $25,366,380 in the previous year. Owing to the depression in the portland cement trade during the latter months of 1903, there was no such remarkable increase in the output as has characterized previous years, although the gain was considerable. The following table shows the production imports and exports of cement in the United States during the past five years:

PRODUCTION, IMPORTS AND EXPORTS OF CEMENT IN THE UNITED STATES.

Year.	Production.				Imports.		Exports.	
	Portland. (a)	Natural Hydraulic. (b)	Slag. (a)	Value.	Barrels. (b)	Value.	Barrels. (b)	Value.
1899. . . .	5,805,620	9,686,447	244,757	$15,860,731	2,810,951	$2,858,286	147,029	$213,457
1900. . . .	7,991,639	9,177,222	490,150	15,393,109	3,182,245	3,330,445	186,586	289,186
1901 (c) .	12,711,225	7,084,823	272,689	15,786,789	1,239,856	1,305,692	384,280	752,057
1902 (c) .	17,230,644	8,044,305	478,555	25,366,380	2,659,721	2,581,883	432,189	575,268
1903. . . .	22,342,973	7,030,271	525,896	31,931,341	3,090,600	3,027,111	417,767	466,140

(a) Barrels of 400 lb. (b) Barrels of 300 lb. (c) Statistics of the United States Geological Survey.

Review of the Cement Industry During 1903.

BY ROBERT W. LESLEY.

The opening months of the year 1903 showed a continuance of the great demand for portland cement which had marked the close of 1902. The dealers and manufacturers were beset with inquiries for large quantities of material upon contracts for work to be done during the year, and the indications were that there would be a repetition of the conditions of the previous year in the shape of a shortage in supply and an increase in demand. All the mills were driven at their full capacity and many new cement works were rushed to completion, while others were rapidly planned, with the object of getting a share of the large business offered. With the coming of May, labor conditions became unsettled, strikes in the building industry began in all parts of the country, operations in the large cities were almost entirely stopped, and the planning of new buildings and important structures came to an end. The effects of all this upon the cement industry were soon perceived, and many of the mills which had held their stocks for the high prices, which it was believed the cement would realize during the summer and fall months, found themselves confronted with large quantities of material on hand and a diminishing market. In a very short time prices fell off, so that at the beginning of the autumn very low figures were made, many of the new cement enterprises were abandoned, and a large number of the mills suspended operations in order to dispose of the stocks of cement on hand. Needless to say, that the price of cement continued to decline, and at the time of the annual meeting of the Association of Portland Cement Manufacturers, which was held in New York on December 8, the lowest prices of the season were made. At this meeting, which was attended by representatives of 45 cement manufacturing companies, figures were given which showed the total quantity of stocks of cement on hand at the mills of the manufacturers on December 1, 1903. The quantity, it was expected, would be very large, but when the figures were compiled it was found that the total stocks on hand, at the date mentioned, were 1,243,933 bbl., or about a month's consumption of the United States.

The question of statistics of the cement industry has given the association considerable thought. During the year there have been sent to all the members reports of the United States Bureau of Statistics, showing the imports and exports of cement, and from these it has been possible to gather some idea of the conditions of our foreign trade, and of the effect of foreign importations upon our domestic industry. Following this line of thought, it has been decided that the association should be made the center of the cement statistics of the United States, and that upon the plans used by the Iron & Steel Association there shall be received by a statistician, to be appointed, monthly or quarterly reports of the stock of cement on hand and of the number of kilns that are in operation, and that these figures shall be tabulated, not according to mills, but according to the districts in which the mills are located, thus enabling the trade to know the condition of stocks on hand and kilns in operation from time to time, as bearing upon the general cement situation in the country.

During 1903 a number of new mills were brought into the productive state in many parts of the country. The Lehigh district, as usual, contributed its fair proportion of the additional output. The capacity of the Michigan mills was also largely increased, as was that of the mills in the Indiana field. While accurate figures of the total output of portland cement for the year 1903 are not as yet accessible, it is estimated that the production for the year 1903 was, in round figures, about 22,000,000 bbl., and that of this production the Lehigh and New Jersey regions furnished, as a whole, in round figures, nearly 60 per cent. There were imported during the twelve months ending December 31, 1903, 2,466,264 bbl. of 380 lb. net, so that the total consumption of portland cement in the United States for the year 1903 may be estimated at over 21,000,000 barrels.

That the future of the portland cement industry is fairly well assured, so far as the old and tried brands are concerned, may be gathered from the fact that every period of depression in prices has been marked by a period of increased new uses for cement, and that whenever the price for portland cement falls materially the employment of that cement in the shape of concrete construction in many new fields almost immediately follows.

The growth of the industry in the United States is exemplified by the great increase in the consumption of both portland and natural cements during the past fifty years. In 1850 the per capita consumption amounted to only 6.46 lb.; in 1860 it was 10.49 lb.; in 1870, 12.77 lb.; in 1880, 13.04 lb.; in 1890, 33.93 lb.; in 1900, 91.82 lb., and in 1902 the consumption was approximately 119 lb. The great expansion between the years 1900 and 1902, when prices were on a very low level, illustrates the thought above expressed.

While the growth of the portland cement industry has been, as above stated, very large, and is constantly increasing, the same cannot be said of the natural cement industry, which had its origin in this country at the time of the construction of the many canals forming the first means of transportation in the United States. These cements, of the character of the Rosendale, Louisville, Milwaukee, Cumberland and Lehigh natural cements, have been used for more than fifty years with entire success, and there is no record of any failure. With care in their manufacture there is no reason why their consumption should not increase. In cases of large masonry dams, it has been found that the substitution of the natural cements for portland cements enabled much larger bodies of masonry to be constructed at the same cost, thus adding to the stability of the structure and giving the same strength. The American natural cements, as well as the American portland cements, have established a world-wide reputation, and manufacturers from foreign countries are finding their way here to study the methods used in the modern well-equipped plants of the cement trade.

CHROMIUM AND CHROME ORE.

While the United States is a large consumer of chrome ore, the supply that comes from domestic mines is inconsiderable. The deposits in California and North Carolina have been worked intermittently, but the competition of foreign ores has so far operated against any expansion of the mining industry. Their remote situation from points of consumption and the consequent high freight costs have been, perhaps, the most serious obstacles, in view of the fact that the foreign ores are transported at low rates and enter free of duty.

PRODUCTION, IMPORTS AND CONSUMPTION OF CHROME ORE IN THE UNITED STATES.

Year.	Production.			Imports.			Consumption.	
	Quantity Long Tons.	Value.	Value Per Ton.	Quantity Long Tons.	Value.	Value per Ton.	Quantity Long Tons.	Value.
1899. . . .	100	$1,000	$10.00	15,793	$284,825	$18.03	15,893	$285,825
1900. . . .	*Nil*	*Nil*	*Nil*	17,542	305,001	17.39	17,542	305,001
1901. . . .	496	7,740	15.54	20,112	363,108	18.05	20,480	368,898
1902. . . .	315	4,725	15.00	39,570	582,597	14.73	39,885	587,322
1903. . . .	150	2,250	15.00	22,931	302,025	13.13	23,081	304,275

The most notable feature in the trade has been the increased importance of the New Caledonia ore, which is now being imported in large quantities. One of the principal consumers, it is reported, has made a long-time contract for extensive deliveries of this ore. The New Caledonia chromite is the highest grade on the market, carrying about 56 per cent chromic oxide, and unusually small amounts of silica. It is thus very desirable for the manufacturer of chemical compounds and ferrochromium. As the material requires no concentration, it can be sold at a low figure. The freight rates from New Caledonia to the United States range from 12s. to 18s. per ton.

In previous years, Turkey has supplied most of the chrome ore consumed in this country, and it still plays a prominent part in the trade. The Turkish chromite is of good quality, though somewhat inferior to the best New Caledonia mineral. That from the Macri mines carries from 48 to 51 per cent chromic oxide, while the product of Daghardi runs about 54 per cent. The ruling prices for New Caledonia and Turkish ores have been $18.50@$19.50 per long ton on board ship. It has been usual to pay a premium of $0.75 per ton for each unit of chromic oxide above 50 per cent, but owing to the recent influx of high-grade ore only $0.40 is now allowed.

There has been little change recently in the technology and uses of chrome ore. The chief consumer in this country is the Kalion Chemical Company, of Philadelphia, Pa., which controls the manufacture of chromium salts, largely used in the dyeing and tanning industries. The Willson Aluminum Company, with mills at Kanawha Falls, W. Va., and Holcombs Rock, Va., made its usual output of ferrochromium. This alloy carries about 70 per cent chromium, and is employed in the manufacture of chrome steel. The use of chrome ore as a lining for furnaces continues to increase gradually, and there seems to be opportunity of extending the market in this direction considerably. Both bricks and lump ore are employed, the former being manufactured by the Harbison-Walker Company, of Pittsburg, Pa.

The new plant of the Chrome Steel Works, at Chrome, N. J., has been completed. The works are equipped for the manufacture of chrome steel plates, angles and bars, for which they have an annual capacity of 60,000 tons. In addition to one 12-in. bar mill and one 112-in. and one 72-in. plate and angle mill, the works have a steel-casting department, which is equipped with two 15-gross ton Siemens acid open-hearth steel furnaces, with an annual capacity of 20,000 tons, and three Siemens crucible steel-melting furnaces, with an annual capacity of 4,000 tons. The machinery with which the Brooklyn works of the company was equipped has been dismantled.

THE WORLD'S PRODUCTION OF CHROME ORE. (*a*) (IN METRIC TONS.)

Year.	Bosnia.	Canada.	Greece.	New Caledonia. (*b*)	New-found-land.	New South Wales.	Norway.	Russia.	Turkey. (*b*)	United States.
1898....	458	1,833	1,367	14,300	657	2,145	*Nil.*	15,467	(*c*)	102
1899....	200	1,796	4,386	12,480	717	5,327	41	19,146	*d* 4,583	102
1900....	100	2,118	5,600	10,474	*Nil.*	3,338	165	18,233	*e* 9,749	*Nil.*
1901....	505	1,159	4,580	17,451	*Nil.*	2,523	85	(*c*)	*f* 40,972	506
1902....	270	817	11,680	10,281	*Nil.*	454	(*c*)	(*c*)	(*c*)	374

(*a*) From the official statistics of the respective countries, except for the United States, which are our own. (*b*) Exports. (*c*) Statistics not published. (*d*) Exports from Salonica and Smyrna. (*e*) Exports from Salonica and Kossova. (*f*) Exports from European and Asiatic provinces.

Australia.—The exports of chrome ore from New South Wales in 1903 were 1,951 long tons, valued at $36,710, against 500 tons, valued at $8,700, in 1902. The ore was obtained from the mines at Gobarralong, in the Gundagai mining division. A new discovery of ore, assaying 52 per cent chromic oxide, was reported during the year.

Austria.—Chromite deposits are found at Dubostica, Bosnia, and are worked by a Viennese company. The output in 1902 was 270 tons.

Canada.—The production of chrome ore in 1903 amounted to 3,383 short tons, valued nominally at $33,830, as compared with 900 short tons, valued at $13,000, in 1902. The output came from Quebec, which is the only province where mining is carried on. The report of J. Obalski, Inspector of Mines for Quebec, for 1903, shows that 3,020 tons of ore were shipped, with a total valuation of $45,300. The chromite deposits are confined to the eastern townships, occurring in a belt of serpentine that also contains the important asbestos mines. The productive district includes the towns of Colraine, Ireland, Garthby, Wolfeston, Ham, Thetford and Broughton.

Most of the output in 1903 was made by the Black Lake Chrome & Asbestos Company, operating in Colraine township. This company erected a new concentrator in 1903 and is preparing to increase its output. Two qualities of ore are marketed, the first grade carrying from 48 to 50 per cent chromic oxide, and the second grade from 40 to 45 per cent. The methods employed in dressing the ore consist in crushing by stamps and concentrating on Wilfley tables.

The American Chrome Company, a Boston concern manufacturing under the name of the Boston Chrome Company chrome products used in tanning, owns a group of mines near Chrome Siding. It has a mill of 10 stamps, and in 1903 made 500 tons of concentrates, which were shipped to Boston. The Montreal Chrome Iron Company and the Thetford Chrome Company were also active last year.

Greece.—The production of chrome ore in 1903 was 8,478 metric tons, against 11,680 metric tons, valued at $140,160, in 1902.

India.—Chromite deposits in the Peshin and Zhob districts, Baluchistan, were investigated in 1903 by the Indian Geological Survey. One of the most promising localities is near Khanozai, in the Peshin district, where an ore body 400 ft. long and 5 ft. wide was found. The ore showed on analysis 54 per cent chromic oxide.

New Caledonia.—The shipments of chrome ore in 1903 amounted to 21,437 metric tons, as compared with 10,281 metric tons in the previous year. The New Caledonian ore is becoming a strong factor in the world's markets, displacing to some extent the Turkish product. Several large cargoes were shipped to the United States last year under the favorable conditions of transport charges, which were about 24s. ($5.76) per ton. Only the high-grade ore carrying from 50 to 56 per cent chromic oxide is exported.

Newfoundland.—Chromite occurs on the west coast of Newfoundland at Bluff Head, Port au Port bay, but the deposits have not been worked in recent years. From 1896 to 1899 they were exploited by the Halifax Chrome Company, which produced in all 5,500 tons of ore. The Humber Consolidated Mining Company owns a property 16 miles from George's Lake, which it is now developing. A tramway is under construction from George's Lake, and it is proposed to transport the ore to Humber Arm for shipment.

Turkey.—The production of chromite during the year, from March 14, 1901, to March 13, 1902, the last year for which complete returns are available, amounted to 38,752 tons. Of this total, the European provinces Salonica, Kossovo and Monastir produced 11,650 tons, and the Asiatic provinces Aidin, Konia, Adana, Angora, Broussa and Daghardi produced 27,102 tons.

Technology.

Manufacture of Chromium Compounds.—Chromic iron is treated[1] with about twice as much sulphuric acid as is necessary to combine with the bases and sufficient quantity of oxidizing agent, such as chromic acid, lead dioxide, manganese dioxide, or a permanganate is added to convert the iron present from the ferrous to the ferric state. At about 150°C. the iron is precipitated as difficultly soluble ferric sulphate from which the solution of chromium can be readily separated.

Determination of Chromium.—To separate chromium from iron and aluminum, G. von Knorre proposes a method based upon the fact that chromium salts in a solution containing only a slight excess of sulphuric acid can be oxidized to chromic acid by boiling for some time with excess of persulphate, preferably ammonium persulphate. The solution containing the metals as sulphates is treated cold with two or three times the quantity of ammonium persulphate required for oxidizing the chromium. Sufficient dilute sulphuric acid to prevent the separation of basic ferric sulphate is then added, the solution diluted to 300 c.c., and vigorously boiled from 6 to 10 minutes. After cooling to about 50° C., a further quantity of ammonium persulphate (about one-half of that added at first), and 20 c.c. of dilute sulphuric acid (sp. gr. 1.16) are added, the solution is diluted to 300 c.c., and boiled again from 15 to 20 minutes. The solution is again cooled, excess of ammonia added, and the precipitated iron and aluminium hydroxides filtered off, and washed with water. The precipitate is dissolved in dilute sulphuric acid, ammonium persulphate added in amount equal to one-half that added at first, the solution boiled from 10 to 15 minutes, cooled, and the aluminum and iron again precipitated by ammonia. In the united filtrates, the chromium is determined by acidifying, reducing the chromic acid to a chromium salt by sodium bisulphite, expelling the excess of sulphur dioxide by heating, and precipitating the chromium by ammonia.

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1 British Patent No. 5,902, March 13, 1903.

COAL AND COKE.

BY SAMUEL SANFORD.

Except in a few fields the coal mining industry of the United States was extremely prosperous during 1903. This prosperity resulted from the growth of manufactures and the consequent demands on railroads during several years of great material development, and from the long strike of the anthracite miners in Pennsylvania in 1902. This strike, coming at a time when the

PRODUCTION OF COAL IN THE UNITED STATES. (SHORT TONS).

State.	1902.			1903.		
	Tons.	Value at Mine.		Tons.	Value at Mine.	
		Total.	Per Ton.		Total.	Per Ton.
Alaska	*e* 4,000	$20,000	$5.00	*e* 1,000	$5,000	$5.00
Alabama	10,329,479	12,498,669	1.21	11,700,753	14,625,941	1.25
Arkansas	2,125,700	2,338,270	1.10	2,300,000	2,960,000	1.30
California	88,460	248,662	2.81	93,026	160,473	2.80
Colorado	7,455,156	8,349,768	1.12	7,651,694	9,182,033	1.20
Georgia and N. Carolina	375,000	450,000	1.20	430,000	537,500	1.25
Idaho	....	....	.....	*e* 4,000	12,000	3.00
Illinois	*a* 30,031,300	28,289,485	0.94	*a* 34,955,073	36,442,917	1.04
Indiana	9,814,880	9,324,136	0.95	11,191,659	12,310,825	1.10
Indian Territory	*a* 2,741,797	4,386,875	1.60	*a* 3,243,692	5,371,146	1.70
Iowa	5,407,144	7,908,004	1.46	5,900,000	9,322,000	1.58
Kansas	5,229,767	7,321,674	1.40	5,875,000	8,812,500	1.50
Kentucky	6,429,419	6,107,948	0.95	7,075,000	7,075,000	1.00
Maryland	5,525,785	6,225,639	1.13	4,400,000	5,500,000	1.25
Michigan	869,228	1,173,458	1.35	1,581,346	2,372,019	1.50
Missouri	4,067,166	5,324,788	1.31	4,265,328	6,739,218	1.58
Montana	1,707,109	2,389,953	1.40	1,500,000	2,175,000	1.45
New Mexico	1,090,373	1,537,426	1.41	1,323,909	1,681,364	1.27
North Dakota	296,800	371,000	1.25	300,000	420,000	1.40
Ohio	23,929,267	24,843,608	1.08	24,573,266	29,487,912	1.20
Oregon	60,000	150,000	2.50	80,000	200,000	2.50
Pennsylvania	98,946,203	106,861,899	1.08	103,000,000	115,360,000	1.12
Tennessee	4,232,332	5,278,921	1.25	4,810,758	6,253,985	1.30
Texas	850,000	1,360,000	1.60	*e* 900,000	1,330,000	1.70
Utah	1 641,436	2,068,209	1.26	1,845,550	2,399,215	1.30
Virginia	3,070,104	3,223,609	1.05	3,500,000	3,675,000	1.05
Washington	2,690,789	5,300,854	1.97	3,190,477	6,380,954	2.00
West Virginia	26,162,173	27,208,660	1.04	*a* 26,882,526	28,226,652	1.05
Wyoming	4,720,000	6,472,000	1.35	4,602,929	8,056,876	1.75
Total bituminous	258,371,987	$285,574,339	$1.11	277,076,986	$327,075,530	$1.18
ANTHRACITE.						
Colorado	67,767	$203,301	$3.00	20,000	$60,000	$3.00
New Mexico	*a* 42,571	117,070	2.51	*a* 35,621	105,794	2.97
Pennsylvania	41,340,929	82,681,858	2.00	75,232,585	157,988,438	2.10
Total anthracite	41,451,267	$83,002,229	$2.00	75,288,206	$158,100,232	$2.10
Grand total coal — Sh. tons	299,823,254	$368,576,568	$1.19	352,365,192	$485,175,762	$1.38
Grand total coal — Met. tons	271,997,872	....	1.31	319,663,605	....	1.52

(*a*) Fiscal year. (*e*) Estimated.

demand for fuel in the great center of consumption was already abnormal, greatly intensified the need and had far-reaching effects. Hence, while in the west demand during 1903 simply represented the wants of railroads, mills and families during a year of prosperity, in the east the conditions were quite different. There was almost a coal famine at the opening of the year, and when the immediate urgent wants of the consumer were satisfied the now fundamental factors that govern coal consumption ruled. The period of industrial prosperity ended, fuel requirements ceased to grow and began to decline. Consequently the bituminous coal markets showed lessening activity during the latter months of the year. The production of anthracite, however, continued large, since supplies at the beginning of the year were exhausted, and dealers and consumers, mindful of their experience during the strike, bought more heavily than they would have usually.

The only coal-mining State to show much reduction in output was Maryland, where the famous Georges Creek seam in the Cumberland region is approaching exhaustion, and must be of lessening importance. There were a few strikes in Pennsylvania of no special importance, and one lasting a month at many mines in Alabama. There were also strikes in Colorado, the most serious being late in the year; these kept the coal output down to about the 1902 figures. In Montana some mines were worked less actively and at some strikes occurred, the result being a decrease in the State's production.

PRODUCTION OF COKE IN THE UNITED STATES. (SHORT TONS.)

	1902.			1903.		
	Tons.	Value at Mine. Total.	Value at Mine. Per Ton.	Tons.	Value at Mine. Total.	Value at Mine. Per Ton.
Alabama	2,210,735	$6,853,278	$3.10	2,693,497	$7,622,528	$2.83
Colorado	790,617	2,134,666	2.70	*a* 1,053,840	3,089,783	2.93
Georgia and N. Carolina	55,000	156,750	2.85	85,546	368,351	4.31
Indian Territory	49,279	197,116	4.00	49,818	227,542	4.57
Kansas	*e* 10,000	21,000	2.10	14,194	50,221	3.54
Kentucky	126,559	272,101	2.15	115,362	305,327	2.65
Missouri	*e* 1,000	3,000	3.00	1,839	5,797	3.15
Montana	55,050	316,549	5.75	45,107	310,882	6.89
New Mexico	*d* 26,012	58,207	2.25	11,050	31,539	2.85
Ohio	*e* 150,000	412,500	2.75	143,913	528,142	3.67
Pennsylvania	14,941,091	31,077,369	2.08	15,639,011	38,930,060	2.49
Tennessee	555,188	1,709,745	3.06	546,875	1,706,722	3.12
Utah	137,765	551,060	4.00	(*b*)	....	.....
Virginia	978,348	1,761,026	1.80	1,176,439	2,724,047	2.32
Washington	40,569	202,845	5.00	45,623	214,776	4.71
West Virginia	2,249,744	4,139,529	1.81	2,707,818	7,115,842	2.63
Other States (*c*)	*e* 750,000	2,250,000	3.00	932,428	3,228,064	3.46
Total coke { Short Tons	23,106,959	$52,116,741	$2.25	25,262,360	$66,459,623	$2.63
Total coke { Metric Tons	20,962,633	....	2.47	22,918,012	....	2.90

(*a*) Includes Utah. (*b*) Included with Colorado. (*c*) Includes Massachusetts, Illinois, Michigan, Wisconsin, New York and Wyoming. (*d*) Fiscal year. (*e*) Estimated.

The total production of coal in 1903, according to the returns compiled by the United States Geological Survey, was 359,421,311 short tons, an increase of 57,830,872, short tons, or 19 per cent over 1902. The total value of the coal at the mines was $506,190,733 tons in 1903 and $367,032,069 tons in 1902, the increase being $139,158,664 or nearly 38 per cent. This percentage of increase in value, almost double that of the increase in production, is due to the causes briefly outlined above. The determining factor being a demand in excess of the supply available, in spite of the many new mines opened and the increased ouputs from old mines. Also, as the great anthracite output in 1902 was cut down by the strike, the figures of anthracite output in 1903 are comparable rather with those of 1901, while the value at the mines during the whole of 1903 averaged higher than during the first five months of 1902. Hence, in 1903 the largest production of anthracite on record sold at a better average price per ton—the exceptional prices obtained for small lots during the strike being neglected—than in nearly 30 years.

IMPORTS OF COAL AND COKE INTO THE UNITED STATES. (IN LONG TONS.)

Year	Coal.					Coke.		
	Anthracite.	Bituminous.	Totals.			Long Tons.	Metric Tons.	Value.
	Long Tons.	Long Tons.	Long Tons.	Metric Tons.	Value.			
1899	61	1,400,461	1,400,522	1,422,930	$3,882,675	27,855	28,301	$142,504
1900	118	1,909,258	1,909,376	1,939,926	5,020,102	103,175	104,826	371,341
1901	286	1,919,962	1,920,248	1,950,972	5,293,273	72,729	73,883	266,078
1902	73,006	2,478,375	2,551,381	2,592,203	7,339,791	107,437	109,156	423,774
1903	151,023	3,295,379	3,446,402	3,501,544	10,004,844	*Nil.*	....	....

EXPORTS OF COAL AND COKE OF DOMESTIC PRODUCTION. (IN LONG TONS.)

Year	Anthracite.		Bituminous.		Totals.		Coke.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1899	1,707,796	$7,140,100	4,044,354	$8,573,276	5,752,150	$15,713,376	280,196	$858,856
1900	1,654,610	7,092,489	6,262,909	14,431,590	7,917,519	21,524,079	376,999	1,358,968
1901	1,993,307	8,937,147	5,390,086	13,085,763	7,383,393	22,022,910	384,330	1,516,898
1902	907,977	4,301,946	5,218,969	13,927,063	6,126,946	18,229,009	392,491	1,785,188
1903	2,008,857	9,780,044	6,303,241	17,410,385	8,312,008	27,190,429	416,385	2,091,875

The anthracite output was 74,313,919 short tons, valued at $152,036,448, compared with 41,373,596 short tons, valued at $76,173,586 in 1902; these figures representing gains of 32,940,324 tons in quantity, or nearly 80 per cent, and of $75,862,862 in value, or nearly 100 per cent.

The production of bituminous coal in 1903 showed an increase of 9 per cent in quantity and a little less than 22 per cent in value, compared with the 1902 figures, so that 57 per cent of the total increase in coal production in

1903, and 54 per cent of the total increase in value, were due to the anthracite output in Pennsylvania.

The production of coke in the United States in 1903, according to the returns of the United States Geological Survey, was 25,262,360 short tons. The number of coke ovens in the United States at the close of the year was 79,187, as compared with 69,069 at the end of 1902. There were 77,188 ovens active during 1903, including 1,956 by-product ovens, and 75,232 beehive ovens. The output of by-product coke was 7.4 per cent of the total. The figures indicate a yield of 72.25 per cent of coke from the coal charge into the by-product ovens and 64 per cent from the beehive ovens. There were 500 coke plants in existence on December 31, 1903, of which eighteen were not completed and forty-one were idle during the year. The total value of the coke produced was $66,459,-623. The year was remarkable for the wide fluctuation in price, Connellsville furnace coke selling as high as $7 for prompt delivery in the early months and below $1.75 at the end. Prices all over the country, however, averaged higher than in twenty-four years previously.

PRODUCTION AND CONSUMPTION OF COAL IN THE UNITED STATES. (IN LONG TONS.)

Year.	Production.	Imports.	Total Supply.	Exports.		Consumption.	
				Domestic.	Foreign.	Tons.	Metric Tons.
1899 ..	225,103,024	1,400,522	226,503,546	5,752,150	6,806	220,744,590	224,276,503
1900 ..	239,567,351	1,909,376	241,476,727	7,917,519	6,740	233,552,468	237,289,307
1901 ..	261,873,675	1,920,248	263,793,923	7,383,393	3,803	256,406,727	260,509,235
1902 ..	267,699,334	2,551,381	270,250,715	6,126,946	7,581	264,116,188	268,342,047
1903 ..	320,911,885	3,446,402	324,358,287	8,312,098	88,469	315,957,720	321,013,043

UNITED STATES EXPORTS AND IMPORTS OF COAL CLASSIFIED AS TO COUNTRIES.

Country.	Exports.			Imports (*a*).		
	1901.	1902.	1903.	1901.	1902.	1903.
Australasia	*Nil.*	*Nil.*	*Nil.*	351,105	324,543	448,193
Canada	5,080,963	4,468,593	6,535,863	1,438,531	1,678,919	1,613,426
Central and South America	291,816	181,004	....	....	....	....
Europe	589,576	186,695	85,189	77,339	456,938	1,322,293
Hawaii and Philippine Islands	71,718	67,673	66,198	*Nil.*	*Nil.*	*Nil.*
Japan	*Nil.*	*Nil.*	*Nil.*	11,068	9,556	61,406
Mexico	551,448	537,708	846,412	19,702	8,037	5
West Indies	735,389	679,988	660,260	*Nil.*	*Nil.*	*Nil.*
Others	62,483	5,285	....	22,217	382	637
Totals	7,383,393	6,126,946	8,312 098	1,119,962	2,478,375	3,446,402

(*a*) Does not include anthracite coal.

Alabama.—Mining was interrupted in Jefferson county, the largest coal producing county in the State, for a month in July, on account of the United Mine Workers of America failing to agree with the Alabama Coal Operators' Association. The differences were finally submitted to a board of arbitration, headed by Judge Gray, of Delaware. The miners secured semi-monthly paydays and an increase in the mining rate of 2.5c. per ton. The output of coal resumed its usual proportions early in August. In Walker county mining did not stop. The output of the State for the year was 11,700,753 short tons, according to the mine inspector, compared with 10,329,479 tons in 1902, an increase of about ten per cent. There were 19,356 persons employed at the mines. The coke production was 2,658,185 tons. During the year several new coal companies were organized, and some began work; several railroad extensions were built to reach coal fields about to be developed, one being built by the Southern Railway to reach the rivers of the Sloss-Sheffield Steel & Iron Company at Flat Top, where over 1,000 men were employed. The Louisville & Nashville Railroad extended its lines in the western part of Jefferson county.

California.—This State is the only one in which coal briquettes are made on a commercial scale. The output of coal in 1903 was 93,026 short tons. The competition of petroleum and of electricity generated by water power tends to restrict the production.

Colorado.—A sympathetic strike of the coal miners in support of the metal miners at Cripple Creek and elsewhere led to a partial suspension of coal mining in the northern fields from November 9 to November 29, and in the southern fields to the end of the year. There were strikes at some mines in the northern fields in the spring. The loss of output by the strikes is estimated by the State mine inspector at 1,200,000 tons. The total output in 1903 was 7,671,694 short tons, compared with 7,522,923 tons in 1902. Of the 1903 total, 5,261,625 tons were classified as bituminous, 1,211,779 as semi-bituminous, 1,148,493 as lignite and 49,797 as anthracite. There were 10,296 men employed in and at the 160 mines in the State, and 1,350 about the coke ovens. The largest single producer is the Colorado Fuel & Iron Company.

Illinois.—The coal production for the fiscal year ending June 30, 1903, according to the State Bureau of Statistics, was 34,955,073 net tons. There were 935 mines in operation, giving employment to 34,995 miners and 14,684 other employees, a total of 49,679, as against a total of 46,005 for the previous year. The average production per day per man was 3.14 tons, as against 3.63 tons for the previous year. The aggregate value of the output was $36,442,917 at the mines, or $1.043 per ton, as against $28,272,050, or $0.942 per ton the year before. In the fiscal year 510 machines were used to mine 7,832,964 tons of coal, or 22.4 per cent of the total product, as against 646 machines for 6,497,123 tons, or 21.6 per cent of the total output the year before. The slight increase in the percentage of machine-mined coal is due to the small differential in the mining wage scale. The number of fatal accidents for the year was 156, or 3.14 per 1,000 employees. This compares with 2.37 per 1,000 employees the year before, the increase being undoubtedly due largely to the reckless use of powder in blasting, because of the run-of-mine system of paying miners. During the year 935 mines were in operation.

Indiana.—According to the State mine inspector the ouput of coal in 1903 was 9,992,553 long tons, an increase of 1,229,356 tons, or nearly 14.25 per cent over the 1902 figures. Of the 1903 total 1,025,940 tons were block coal and 8,966,613 tons were bituminous; 3,404,078 tons were machine-mined; 5,009,081 tons were consumed in Indiana, and 4,983,472 tons were shipped to points outside of the State. There were 184 mines working more than ten men each; thirty-seven new mines were opened during the year, and eleven were abandoned. The total number of all employees was 15,128, who earned an average of $604 for the year. The increased output was due to the unusually large number of new mines opened and to the heavy demand for fuel accompanying a decline in the State's natural gas supplies. There was considerable complaint of poor service by the railroads; with better service the output of the mines would have been larger, particularly in the last few months of the year. Probably 40,000 acres of coal rights were purchased by investors during the year, and much new equipment was installed at the mines. There were no strikes of employees, and the year ranks as the best in the history of the Indiana coal industry.

Michigan.—The State Commissioner of Labor states that 1903 was a prosperous year for Michigan coal operators, more coal being mined than in any year since the industry started in the State. There was an average of thirty mines in operation, against twenty-one in 1902, and the average number of employees was 3,149, against 1,415 the year before. The wages of employees averaged $2.91 in 1903, and $2.75 in 1902. The total cost of mining coal in 1903 was about $2,482,000, an average of $1.37 per ton, since the total output was 1,581,346 short tons.

Missouri.—The State coal mine inspector reports that the output of coal in 1903 was 4,265,328 short tons, compared with 4,063,572 tons in 1902, an increase of about five per cent.; the average selling prices at the mine were $1.58 in 1903 and $1.31 in 1902, and the total value at the mines showed a gain of 26.4 per cent for 1903. There were 348 mines operated, employing an average of 9,177 men throughout the year. A feature of the industry is the use of longwall mining, mines at 141 places using the system, and at 164 places the room-and-pillar system. The industry was never more prosperous than in 1903; the demand for coal kept the mines in operation, except for a few instances, throughout the year, while miners' wages were increased.

Ohio.—According to the State mine inspector, the entire output for 1903 was 24,573,266 short tons, a gain of 643,979 tons over 1902, and the largest output recorded. There were 912 mines in operation in the State, and the total number of employees in the industry was 41,396. Of the total output 14,560,931 tons were mined by machinery. The changes during the year were rather in the direction of improvements at existing mines than in the opening of new mines.

Pennsylvania.—One of the striking features of the coal industry of this country is the dominating position of Pennsylvania among the States. It has only about one sixty-sixth of the land area of the Republic, yet produces about one-half of the coal. The drain on the State's fuel resources, though enormous, will continue and increase, in spite of the exhaustion of parts of the Connellsville coking coal field. According to the report of the State Department of Mines, the output of anthracite in 1903 was 67,171,951 gross tons, the amount shipped from the collieries by rail was 60,231,104 tons and the total number of persons employed was 151,827. The anthracite fields have been so thoroughly explored that discoveries of new seams of coal are practically impossible. The developments during the year were chiefly in the direction of centralizing scattered equipment at large power plants, sinking deep shafts, erecting larger breakers and extending the use of electric power about the mines. The collieries employed 151,827 persons and worked an average of 211 days during the year. There were no strikes of importance, except at the Red Ash colliery, near Wilkes-Barre.

In the bituminous regions a great amount of new work was done. In the Beach Creek region the Beach Creek Coal & Coke Company made progress. The Pennsylvania Coal & Coke Company took over the operation of a number of mines in Cambria county, including the holdings of the Webster Coal Company at Ehrenfeld; in Indiana county an immense amount of work was done about Ernest by the Rochester & Pittsburg Coal and Coke Company. In southwestern Cambria county the Lackawanna Iron & Steel Company completed the erection of a large washery at Wehrum. In Somerset county the miners employed by several companies near Meyersdale struck in December, and some rioting followed attempts to work the mines. In northern Somerset county the Windber mines of the Berwind-White Company had a most successful year. In the Westmoreland region new work was carried on.

The production of coal in the Pittsburg district in 1903 exceeded expectations and was the heaviest on record. The output for the year was 29,379,295 tons, or about 5,000,000 tons ahead of 1902. The capacity of the leading companies greatly increased, but shipments were not as large as they would have been had the railroads furnished more cars. The Pittsburg Coal Company sent up the lakes about 4,500,000 tons, or 1,200,000 tons more than in 1902. The total production of the Pittsburg Coal Company for the year, from ninety-one mines, was 21,039,968 tons, exclusive of the Midland Coal Company properties. The New York & Cleveland Gas Coal Company produced 1,155,248 tons from seven mines; Shaw Coal Company, 400,000 tons, and Mansfield Coal & Coke Company, 403,496 tons. The production of the Monongahela River Consolidated Coal & Coke Company, the river combination, was 7,070,153 tons from thirty-nine mines. Of this amount 2,000,000 tons were shipped by rail and the rest by water. Of the river shipments, fully 2,500,000 went to local markets and 3,000,000 tons to southern ports. Several important deals were made by the Pittsburg Coal Company during the year. In January it took over the Midland Coal Company, operating three mines and owning 5,000 acres of valuable coal land in the Panhandle field. The property of the Mansfield Coal & Coke

Company, which included one mine, 1,000 acres of land and a number of individual railroad cars, was taken over in November. The majority of the stock of the Monongahela River Consolidated Coal & Coke Company was purchased in October.

The Pittsburg & Buffalo Company, the largest independent concern in the Pittsburg district, and its constituent companies, the Manufacturers & Consumers Coal Company and the Johnetta Coal Company, were consolidated in December as the Pittsburg-Buffalo Company, capitalized at $6,000,000. The production in 1903 was 1,500,000 tons. The company owns the Hazel mine at Canonsburg, and besides working seven other mines was opening eight new mines at the end of the year. The Pittsburg Railroad Terminal & Coal Company, a new concern, purchased 7,000 acres of coal land in the heart of the Pittsburg district and opened seven mines, which during the year produced about 400,000 tons.

The joint annual convention of the United Mine Workers and the operators of Pennsylvania, Ohio, Indiana and Illinois, parties to the inter-State agreement, agreed in January on a new mining rate for the year beginning April 1. This provided for an advance of 12½ per cent for pick mining, fixing the price at 90c. a ton for coal over a 1¼-in. screen; 16 per cent advance for machine miners and 21 per cent for drivers. There was a great scarcity of coal in January as a result of conditions in 1902; run-of-mine coal brought from $6 to $7 a ton, and contracts for the year were made at good prices; but in the fall there was a heavy decline, and in December run-of-mine coal sold as low as 90c. at the mine. The mine prices for the year averaged $1.70 for run-of-mine; $1.90 for 1¼-in.; $1.80 for ¾-in., and $1.15 for slack.

In the Connellsville region comparatively little improvement was made except the installation of better equipment. In the extensions of the Connellsville field, however, several large mines were opened.

Tennessee.—The coal mines worked during the year employed 9,673 persons, the mine inspector states. There was an increase in production of 578,426 short tons over 1902, or 13.67 per cent. Of the total output there were shipped 3,734,434 short tons, or 77.63 per cent; used for fuel, 94,534 tons, or 1.96 per cent; used for steam, 45,863 tons, or 0.95 per cent; sold locally, 35,985 tons, or 0.75 per cent, and coked, 899,946 tons, or 18.71 per cent. There were 1,498 coke ovens in operation during the year, and 280 building at the end of the year. There was considerable new development in the coal fields, but only about 30 per cent of the increased output is due to this, as most of the new openings lacked railroad facilities; twenty-eight new openings were to begin shipping in 1904, and the output is expected to increase as the railroads make extensions and put in spurs.

Washington.—The State inspector of coal mines reports an output of 3,190,477 short tone in 1903, an increase of 18.57 per cent over the 1902 figures. Of this total 2,241,568 tons were used in the State and 948,909 tons were exported.

The value of the coal at the mine was approximately $2 per ton. Coke ovens in Pierce county made 47,916 tons of coke, valued at $5 per ton at the oven. There were 4,876 miners and other laborers employed, who worked an average of 306 days at $2.67 per day.

West Virginia.—(By James W. Paul.) As 1903 opened with an unusual demand for coal, and as the price received early in the year for all grades was abnormal, coal mining in the State has never been more profitable to those not shipping under old contracts. In the first six months of the year there were mined 13,002,255 long tons of coal, and there were manufactured 1,409,390 tons of coke. During the last six months of the year a scarcity of railroad cars and a lessened demand for coal and coke materially reduced the tonnage. The production for the year was: Coal, 24,002,255 long tons; coke, 2,409,390 net tons. An idea of the progress of mining within recent years may be had when it is stated that the coal production of the first six months of the year was 1,296,426 tons in excess of the State's production of the entire year 1897, and the coke production for 1897 was less than for the first half of 1903 by 34,893 tons.

The detailed report for the fiscal year ending June 30 reveals the production for that period to be: Pick-mined, 16,600,804 tons; machine-mined, 6,312,894 tons; total, 22,913,698 long tons. Of this amount 266,691 tons were used for steam purposes at the mines, 210,273 tons were sold to the local trade, 3,774,674 tons were manufactured into coke, and 18,662,060 tons were shipped to points mostly out of the State.

This production was distributed as follows: Potomac district, 1,662,068 tons; Monongahela, 6,679,000 tons; Wheeling, 503,925 tons; Kanawha-New River, 6,540,325 tons; Norfolk and Western, 7,388,380 tons; small mines, 180,000 tons; total, 22,913,698 tons.

The largest producing companies, in their order, were: Fairmount Coal Company, 3,580,604; Davis Coal & Coke Company, 1,341,265; Kanawha & Hocking Coal & Coke Company, 709,753; Norfolk Coal & Coke Company, 591,982; Red Jacket Coal & Coke Company, 506,443; Clarksburg Fuel Company, 477,176; Crozer Coal & Coke Company, 274,381; Houston Coal & Coke Company, 272,736; Junior Coal Company, 265,855; Turkey Gap Coal & Coke Company, 254,352; Empire Coal & Coke Company, 253,607; a total for eleven companies of 8,528,154 tons, or 37 per cent of the State's output. The mine which produced the greatest tonnage was the New England, in Marion county, belonging to the Fairmount Coal Company. This mine yielded 305,120 tons from one opening, a drift.

There were 795 machines used for 1903, an increase of 261 over the previous year, and the firms using them were 181, an increase of 57.

There were employed in the mines 16,287 pick miners, 6,531 machine men, 7,632 inside laborers, making a total of 30,450 inside; 3,851 coke workers, 5,151 outside laborers, a total outside of 9,002, or a total of all kinds of labor at the mines of 39,452. The mines in the State worked an average of 213 days during the year, and the coke ovens 223 days. The average price paid for mining run-of-mine pick coal was 49.5c. per ton, the highest figure on record. The average price received at the mines per ton of 2,240 lb. for run-of-mine coal was $\$1.32^2/_3$, and for coke per ton of 2,000 lb. $\$2.66^1/_4$.

There was an increase of 84 shipping mines, and the development throughout the State was unsurpassed by any previous year. Many large tracts of land were acquired by corporations and individuals, and large tracts of mineral rights have been secured by prospective operators. At least forty-five mines have been opened on tributaries of the Great Kanawha River east of Charleston, notably on Cabin, Paint and Kelleys creeks. On Tug River the United States Coal & Coke Company opened six mines, completed 1,500 coke ovens and has as many additional in contemplation. At Gary is the central electric power plant, the largest within the State. In Fayette county several shafts were started to reach the New River coals at points south of the New River cañon, where these coals are below drainage. In the Belington field many substantial improvements were made, and the capacity of the mines much enlarged. In the counties near Wheeling there was great activity.

Wyoming.—Coal mining began in 1867. The most famous district is the Rock Springs field in Sweetwater county. This coal is in the lower Laramie series of the Cretaceous, and the same formation contains 90 per cent of the coal area of the State, estimated at 20,000 square miles, showing three to nine seams of coal, most of it classified as lignite. The only coking coal in the State is a semi-bituminous found at Cambria, on the western edge of the Black Hills. It is shipped to Deadwood, S. D., where about 16,000 tons of coke are annually made from it. The total output of the State in 1903 was 4,602,929 short tons, valued at $8,056,876; the number of men employed was 5,723.

Coal Production in Foreign Countries.

The world's production of coal in 1903 was by far the largest on record. In 1902, owing to labor troubles and disturbed business conditions, the output in Germany, Austria and Russia was lower than in 1901, while owing to the strike in the anthracite coal regions of Pennsylvania the output of the United States was kept down. In 1903, however, industrial prosperity in the United States had reached its maximum, the fuel shortage of the previous year created an unprecedented demand for coal, and the total output increased enormously. In Germany a great revival of industrial activity stimulated mining. In fact, five out of six of the leading coal-producing countries—the United States, Great Britain, Germany, Austria-Hungary, France and Belgium—increased their outputs in 1903 over any previous figures, and the world's output was by far the largest recorded. The individual outputs of different countries are shown in the following table:

COAL PRODUCTION OF THE CHIEF COUNTRIES OF THE WORLD. (METRIC TONS.)

Years.	1898.	1899.	1900.	1901.	1902.	1903.
South Africa *a*	*b* 550,485	*b* 239,443	759,362	1,388,205	2,386,402	3,131,832
AUSTRALIA:						
New South Wales	4,781,551	4,670,580	5,595,879	6,063,921	6,037,083	6,456,524
Queensland	414,461	501,903	505,252	547,624	509,579	516,925
Tasmania	49,902	43,803	51,549	46,165	49,647	49,069
Victoria	246,845	266,578	215,052	212,678	228,767	65,227
Western Australia.	330	55,208	120,305	119,721	143,145	133,426
New Zealand	921,546	990,838	1 111,860	1,247,280	1,384,570	1,442,916
Austria-Hungary (*c*.)	37,786,962	38,738,372	39,027,929	40,746,704	39,386,884	39,600,000
Belgium	22,088,335	22,072,068	23,462 817	22,213,410	22,877,470	23,871,000
CANADA:						
British Columbia and Territories	1,454,452	1,601,833	1,791,826	1,861,248	1,826,221	2,054,360
New Brunswick, Nova Scotia	2,330,890	2,866,144	3,296,322	3,788,168	4,699,396	5,200,186
France	32,356,107	32,862,712	33,404,298	32,325,302	29,997,470	35,002,992
Germany (*c*.)	127,958,550	135,844,419	149,788,256	152,628,931	150,600,214	162,619,934
India	4,678,640	5,106,055	6,216,822	6,742,176	7,542,784	7,600,278
Italy	341,327	388,534	479,896	425,614	413,810	400,300
Japan	6,651,208	6,721,798	7,429,457	8,945,939	9,857,537	*e* 10,200,000
Russia	12,307,450	14,274,361	14,759,866	16,156,038	15,503,430	*e* 16,200,000
Spain	2,466,800	2,600,279	2,582,972	2,651,857	*c* 2,826,637	*c* 2,798,113
Sweden	236,277	239,344	252,320	271,509	304,733	320,390
United Kingdom	205,287,388	223,616,279	228,772,886	222,614,981	230,728,563	234,009,484
United States	198,071,199	228,717,579	243,414,164	266,078,668	273,600,961	326,064,592
All other Countries	*e* 2,500,000	*e* 2,500,000	*e* 2,500,000	*e* 2,500,000	*e* 3,500,000	*e* 4,000,000
Totals	665,480,705	724,828,145	766,935,262	787,935,262	804,405,203	881,737,550

(*a*) Transvaal, Natal and Cape of Good Hope. (*b*) Includes estimates of 50,000 tons for Orange Free State and Transvaal, for which no statistics are available. (*c*) Including lignite. (*e*) Estimated.

Of the chief coal producing nations the United States, Great Britain and Germany export more coal than they import, and are also the world's largest consumers.

The following table summarizes the production, imports, exports and consumption of coal in 1902 by the chief producing countries:

CONSUMPTION OF COAL IN 1902 IN CHIEF PRODUCING COUNTRIES. (METRIC TONS.)

Country.	Production.	Imports.	Exports.	Consumption.
Austria-Hungary (*a*)	12,208,000	6,314,000	927,000	17,595,000
Belgium	22,877,000	3,496,000	6,574,000	19,799,000
France (*a*)	29,365,000	13,641,000	1,017,000	41,989,000
Germany (*a*)	107,474,000	6,870,000	18,981,000	95,363,000
Japan	9,858,000	73,000	2,939,000	6,389,000
Russia	15,503,000	3,310,000	51,000	18,762,000
United Kingdom	230,729,000	3,000	61,366,000	169,366,000
United States	273,601,000	2,592,000	6,225,000	269,968,000

(*a*) Excluding lignite.

The exports in the table are complicated by the lack of uniformity in different countries regarding what is known as bunker coal. Thus the figures of exports from France and the United Kingdom include coal used in steamers engaged in foreign trade, while coal for steamers in coastwise trade is excluded. The United States figures do not include the coal shipped for use by steamers in foreign trade. In Germany all coal shipped as bunker coal is excluded from the import and export accounts, but coal shipped from other parts of the empire to the free port of Hamburg is included in the exports. The Japanese returns no longer include the coal used for ships' use. In the United Kingdom in 1903 16,799,848 long tons of coal were shipped for the use of steamers in the foreign trade, and in the United States in the same year about 8,196,995 long tons were required for fuelling vessels, including vessels on the Great Lakes. Of this total, 5,072,627 tons were for vessels going to foreign ports and 3,106,311 for vessels going to coastwise ports.

The consumption of coal per head of population is naturally greatest in those countries having the most railroad mileage in proportion to population, and where steam machinery is most used. The consumption per head in the United States and in Great Britain is about the same; Belgium is the only country where the consumptive demand approximates that of these two. In France and Germany the small consumption per head is due to the extensive use of lignite, wood and peat for household purposes. The figures of per capita consumption for 1903 are, in metric tons: United States, 3.99; United Kingdom, 3.99; Belgium, 3.07; Germany, 1.75; France, 1.19; Russia, 0.13; Austria-Hungary, 0.38. The proportion of native to imported coal consumed in the different countries was approximately as follows: United Kingdom, 100 per cent; United States, 98.94; Germany, 92.84; France, 71.31; Belgium, 81.76; Russia, 82.36; Austria-Hungary, 66.91 per cent.

An interesting feature of the world's consumption of coal is the amount used by locomotives. A report issued by the British Board of Trade gives the quantity so consumed in Great Britain in 1903 as 11,399,413 long tons, and in the preceding year 11,336,522 long tons. The French railways used 5,401,000 metric tons in 1902, the Belgian State railways 1,328,000 metric tons, and the railways of British India 2,120,000 long tons. The amount used by railways in the United States has been estimated as high as 100,000,000 tons annually.

The progress of the development of the world's coal fields during 1903 is briefly outlined in the following pages. This progress is notable for being a general movement, as shown by the table of production of the different countries, while new developments and increased production have been recorded by countries not mentioned in the table. Progress was naturally most marked in the West, but in the coal fields of the East some advance was made.

Austria-Hungary.—The settlement of strikes, which had reduced output in 1902, and better trade conditions led to a considerable increase in the output of coal. In Austria the coal mines produced 11,620,275 metric tons, an increase of 470,340 tons, and the lignite mines 22,214,490 tons, an increase of but 14,103 tons over the 1902 figures. The coke production in 1903 was 1,168,263 tons and the output of briquettes 179,133 tons. The chief mines are in Bohemia. The total production of coal and briquettes in Austria-Hungary in 1902 was 39,386,884 metric tons; the imports of coal were 6,314,000 tons, and the exports 927,000 tons.

Belgium.—The coal output in 1903 exceeded the figures for 1900, the most prosperous previous year, and was 1,102,000 tons greater than for 1902. In 1903 there were 119 mines worked, and the greater quantity raised was chiefly due to increased activity in the Mons, Charleroi, Liège and Seraing coal fields. The total production was 23,871,000 metric tons.

Canada.—The production of coal in 1903 was kept down by strikes and accidents in different fields, but the year's total exceeded the 1902 figures. The tonnage of coal, nearly all bituminous, mined in the Dominion in 1903 was 7,529,753 long tons (7,996,634 short tons). In 1902 the total output was 7,193,142 short tons, valued at $14,478,181, of which 5,161,316 tons were mined in Nova Scotia, 1,534,902 tons in British Columbia, 478,129 in the Northwest Territories and 18,795 in New Brunswick. The total imports for the fiscal year 1902 were 3,047,392 tons of bituminous coal and 1,652,451 tons of anthracite, a total of 4,699,843 tons. The exports amounted to 2,113,721 tons. The total consumption was 10,268,812 tons, of which 49.7 per cent was Canadian produce and 50.3 per cent imported.

In the Sydney district, Cape Breton, Nova Scotia, the Dominion Coal Company opened more ground and increased shipments, though one shaft caught fire and was flooded, checking production. The company mined in 1903 3,147,766 short tons. Other coal companies in the colony were busy early in the year owing to the demand from the United States, but worked less actively in the last half. The total production was 5,245,247 tons, of which Cape Breton produced 3,719,400 tons, the Cumberland district 593,475 tons and the Pictou 697,743 tons.

In British Columbia the 1903 output was 1,450,662 long tons. The collieries at Nanaimo, formerly worked by the New Vancouver Coal Company, were taken over by the Western Fuel Company, a California concern. The output of Vancouver island collieries was 860,775 long tons, a decrease of 346,036 tons from the 1902 figures, and 400,713 tons were exported to the United States. The Crow's Nest Pass collieries during 1903 mined 589,888 short tons of coal, or nearly 50 per cent more than in 1902, of which 340,337 tons were sold and 249,551 tons made into coke, yielding 149,764 tons of that commodity, the coke output thus increasing 41,927 tons over 1902, or nearly 39 per cent. Home consumption of coke increased 40,993 tons, or 50 per cent. The demand at home kept down exports, which were about the same as for the year before. The capacity of the coking plants at Crow's Nest Pass, Morrissey and Michael is being increased. .

In the Yale district the lignite deposits near Nicola were prospected. In Alberta the International Coal & Coke Company began work at Coleman, opening mines to have a daily capacity of 400 tons, while mines at Frank were closed by a great landslide in April, and did little for months afterwards.

France.—The production of bituminous coal and lignite in 1903 was 35,002,992 metric tons, or nearly 17 per cent over 1902. The lignite production was 685,465 tons and the coal 34,317,527 tons. Of the coal about 1,580,000 tons were anthracite. The chief French coal fields are in Pas-de-Calais and Nord. Considerable exploration work undertaken to determine a southwestern extension of the Pas-de-Calais gave indifferent results. The imports of coal, coke and briquettes into France in 1903 were as follows: Coal, 11,208,460 metric tons; coke, 1,521,550 tons; briquettes, 628,190 tons; total, 13,358,200 metric tons. The exports were: Coal, 984,470 tons; coke, 106,330 tons; briquettes, 70,790 tons; total, 1,115,590 metric tons. The consumption of bunker coal and briquettes by French ships in 1903 was 1,078,500 metric tons.

Germany.—Germany ranks third among the world's producers of coal and lignite. Its importance is due to the rapid development of its resources, the organization and development of production and the methods used for distributing sales. The whole production of Germany in 1903 was: Bituminous coal, 116,664,376 metric tons; lignite, 45,955,558 metric tons; a total of 162,619,934 metric tons, as compared with 150,600,214 metric tons in 1902. In 1903 the output of coke was 11,509,259 tons, and of briquettes 10,476,170 tons. Prussia alone yielded 108,989,879 tons of coal, 38,460,232 tons of lignite, 11,446,652 tons of coke and 9,173,681 tons of briquettes. The Prussian coal fields contribute to the output as follows: Saar, 9 to 10 per cent; Upper Silesia, 24 to 25 per cent; Westphalia, 60 per cent; others, 5 to 7 per cent.

Of the German imports of coal, amounting to 6,766,513 tons in 1903, 5,393,828 tons came from Great Britain and 613,758 tons from Austria-Hungary. The exports in 1903 were 17,388,149 tons, of which 5,658,974 tons went to Austria-Hungary and 5,179,448 tons to Holland; but the figures of exports to the latter country are misleading in that a considerable part of the coal is detined for French and even Mediterranean ports.

About 460,000 persons are employed in the coal mines and about 60,000 persons in the lignite mines. The Prussian government owns mines in Upper Silesia, near Saarbrücken, and in Westphalia, near Lippe.

Germany surpasses all the other nations in the utilization of low-grade coal and lignite by briquetting. In Prussia these lignites are chiefly in the Lausitz district, southeast of Berlin, and on the west bank of the Rhine near Cologne. In these two districts are 280 factories containing 680 presses, which in 1902 made 12,438,000 metric tons of briquettes. One company, near Halle, has 15 plants and makes 3,000 metric tons of briquettes daily.

A conspicuous development of the German coal trade, as of some other industries in that country, is the growth of strong syndicates of producers, which openly or secretly aim to restrict output to the supposed needs of the market, each producer shipping an amount proportionate to the capacity of his collieries; to maintain prices at a fixed level for certain periods, and to extend sales in competitive markets by price concessions. The most noted of these is the Rhenish-Westphalian Coal Syndicate. This includes a large majority of the colliery owners in the northern Rhenish-Westphalian provinces, and together with the Westphalian Coke Syndicate and the Dortmund Briquette Syndicate forms the Kohlen, Handel und Rhederei Gesellschaft, which includes all wholesale dealers in Westphalian coal who annually handle over 56,000 tons.

A syndicate of colliery owners in the Westphalian coal basin was formed in 1892, and renewed for ten years in 1895. In 1903 it was reconstructed on a broader basis and with greater powers. This syndicate sells from the participating properties coal, coke and briquettes. The total annual productive capacity is now put at 77,840,000 metric tons, or two-thirds the production of Germany. The contract under which the syndicate is established allows each colliery owner one vote for every 10,000-ton share of sales; creates a council composed of one member and one substitute for each million tons of participating capacity, and a commission of eight members, which annually fixes the allotment figures. The sale of coal, coke and briquettes is by the syndicate, which is bound to act for all properties controlled. The prices are fixed for a year; they may be increased, but cannot be lowered, and whatever the profit, it falls to the individual mine which supplied the coal. Coal, coke and briquettes necessary for operating mines and works, or for the use of employees, are not sold by the syndicate, but participants are not permitted to get such supplies from concerns not in the syndicate. In short, the society aims to unite under one body all transactions in coal. To this body the syndicate ceded the sale of its products in Holland, Switzerland and in western Germany; but there are several exceptions to and reservations of the power of this central sales body. For instance, it does not control the sale of coke to blast furnaces. The final result, however, is the concentration of the production of the mines of Westphalia and of western Germany, outside of those owned by the State, and the distribution and sale of coal, coke and briquettes under the direction of the syndicate and of a body in which the syndicate's interest is controlling.

The Rhenish-Westphalian syndicated mines in 1903 shipped or sold locally 39,071,554 metric tons of coal, 8,606,575 tons of coke and 1,696,673 tons of briquettes. At the collieries were consumed 14,776,286 metric tons of coal, of which 10,799,307 tons were used in making coke, 1,558,956 in making briquettes and 2,410,023 tons for fuel. The shipments from the three ports on the Ruhr were about 10,900,000 metric tons. The syndicate divides its field of operation into a contested and an uncontested district. In the former, price concessions are often made, especially to foreigners; in the latter, embracing practically all Germany, west of Saxony and the Elbe, the syndicate's rule is now absolute, though independent concerns are able to thrive under the protection afforded by it from outside competition.

Italy.—The output of coal, lignite and bituminous schist in Italy in 1902 amounted to 413,810 metric tons. There were 19 mines in the province of Firenze and 9 in Vicenza. There were in the kingdom 126 active works for briquettes; there were made 694,000 tons, mostly from coal.

Mexico.—Considerable new work was done in the coal fields of the Republic in 1903. The coal fields so far developed are almost all in the eastern part of Coahuila. The northern coal field, in the Rio Grande valley, produces gas coal; the other coal field worked is in the Sabinas valley and contains the Sabinas and Esperanzas basins, both of which produce coking coal, though the seams are rather dirty. The output of the republic in 1902 was 709,654 metric tons, of which the Coahuila Coal & Coke Company produced 282,000 metric tons, the Fuente Coal & Coke Company 395,054 metric tons. The coke output was 71,710 metric tons. In the same year 761,938 metric tons of coal and 175,395 tons of coke were imported, not including supplies for works in Sonora. The estimated output of coal in 1903 was 850,000 metric tons, and of coke 85,000 metric tons.

Russia.—In 1902 production fell off, but the 1903 output probably exceeded the 1901 figures. The most import coal field is the Donetz basin, where Carboniferous deposits cover an area of 7,720 square miles. The coal seams are numerous, but generally thin, and the coal varies from a good gas coal to an excellent anthracite. About two-thirds of the total output of European Russia comes from the basin, and about 95 per cent of the output of the basin is from the Don Cossack territory. There are about 140 collieries at work, with a possible capacity of 20,000,000 tons. Southern Russia, including the Donetz basin, yielded 12,386,289 metric tons of coal in 1903, about 12 per cent of this being anthracite. The Dombrowa basin in Poland gave from 27 mines 4,747,812 metric tons, about one-quarter of the total output, and mines near Moscow and in the Urals produced small amounts. The Russian output in 1902 was 15,502,530 metric tons. The imports were 3,445,030 tons, and the exports 50,182 tons. The home consumption was 18,897,378 metric tons.

Spain.—The principal coal mines are in Asturias. Improved shipping facilities, lower railroad freights and the development of manufacturing are necessary for the growth of coal mining. Disturbed industrial conditions interfered with demand in 1903. The production was 2,700,835 metric tons of coal and 97,278 metric tons of lignite, a total of 2,798,113 tons. In 1902 the figures were: Coal, 2,735,620 tons; lignite, 91,017 tons; total, 2,826,637 tons. There were 450,474 tons of coke and 339,120 tons of briquettes made in 1903. In the same year the total imports of coal were 2,085,429 tons, and of coke, 258,167 tons, chiefly from Great Britain. The coal exports were insignificant, amounting to 3,127 tons, and the nominal consumption of coal was therefore 4,783,137 tons.

Turkey.—Of the European countries Turkey produces annually over 250,000 metric tons of coal and lignite. The lignite deposits are widely scattered, and worked in a small, crude way. The most important coal mining district is near Heraclea, on the Asiatic coast of the Black Sea, where a French company has opened mines with a capacity of 1,000 tons daily.

United Kingdom.—The demand for coal during 1903 was better than in 1902. The improvement was both in coal for home consumption and for export, the total production increasing 3,239,427 long tons, and the exports 1,651,733 tons over the 1902 figures. The total production was 230,334,469 long tons, valued at 7s. 8d. ($1.86) per ton at the mine. Of this total the mines in

Ireland produced 102,812 tons; in Scotland, 34,992,240 tons; in England, 145,963,550 tons, and in Wales, 58,265,793 tons. There were 10,174 tons of coal taken from open quarries.

There were comparatively few labor disturbances in the coal mining districts and no widespread strikes; neither were there important new developments in the organization of the trade, or in the discovery of possibly new sources of supply at great depths. The total number of persons employed at the coal mines was approximately 822,000, of whom 660,400 worked underground. The average production per person employed was 280 tons per annum.

The total coal imports of the United Kingdom in 1903 were estimated at but 3,000 long tons. The total exports amounted to 46,622,700 long tons, of which 44,950,057 tons were coal and culm, 717,477 tons coke and cinders and 955,166 tons briquettes. The total quantity of coal, etc., shipped for steamers in the foreign trade, not included above, was 16,798,848 tons. The navy requires about 1,000,000 annually of Welsh coal and of briquettes made chiefly from dock screenings. In addition the navy uses about 122,000 tons of foreign and colonial coal. Of the exports, 7,122,575 long tons went to France, 6,118,-323 tons to Germany, and 6,424,608 tons to Italy. Protests by colliery owners against the export duty continued, but it does not appear that the duty caused English shippers to lose business, except in a few markets where the German syndicate would likely have underbid any price made by British shippers.

South America.—Little has been done with the coal fields of Colombia. In Peru the development of metal mines has led to larger outputs of coal, but railroads are needed as well as more diversified industries to lead to any great activity in coal mining. In Chile bituminous coal is found in rocks of Tertiary age that form a large belt in the southern part of the republic. The belt is widest in the province of Arauco. The best coal comes from the Sota and Corinel mines, and contains about 50 per cent of volatile hydrocarbons. The total annual output of Chile is about 900,000 metric tons, of which 300,000 tons go to vessels, 265,000 tons to coastwise parts, and the rest to works in the interior. The imports in 1902 were 750,000 tons.

Australia and New Zealand.—The output of coal in Australia increased little in 1903. The mines in Victoria were closed a large part of the year by strikes. New South Wales, the most important coal producing State, had an output of 6,354,846 long tons in 1903, compared with 5,942,011 tons in 1902. Most of the product is exported, and of late years there has been a notable increase in the shipments to points outside of Australia, except to South African ports, owing to the development of the coal mines of that country. Of the total exports in 1903 3,716,194 long tons, 1,761,003 tons went to other Australian States and the balance to other countries. A new coal field has been opened at Kurri-Kurri in the northern part of the colony. The amount of coke produced in the State was 160,592 tons. The only coal field in Western Australia is at Collie and produced 140,882 long tons in 1902. The coal output of New Zealand in 1902 was 1,384,570 long tons, more than half of this being bituminous coal. A large part of the tonnage comes from the Westport district.

Africa.—In South Africa the coal mines made gains in 1903. In the Transvaal there were 24 collieries busy in what is known as the Boksburg district, and the total output of the colony was 2,258,284 short tons. The largest individual producer was the Witbeck colliery—378,281 short tons. The mines in the Springs basin are nearly worked out, but those about Middleburg have large capacity, and there is no lack of fuel for the gold mines. In Rhodesia the Wankie collieries shipped 46,870 short tons in 1903. In Natal the collieries produced 713,548 long tons of coal, of which 298,873 tons were exported. In Cape of Good Hope the mines yielded less coal in 1903 than in 1902. The coal production of Orange River colony continues small, but considerable exploration is under way. In northern Africa a little coal is mined in Algiers, the reported output in 1902 being 285 metric tons.

Asia.—Much of the coal used on the Trans-Siberian Railway comes from mines near Tscheremchow in the government of Irkutsk. In eastern Siberia and in Mongolia it seems that mines of which much was expected a few years ago have proved disappointing. The mines on Saghalien, worked by Russian convicts, have produced coal not of the best quality. At Su-chan, a new mine of much promise was opened early in 1902, and a railroad was under construction during 1903 to connect the mine with the Ussuri line and permit shipments to Vladivostok, 100 miles distant. The coal from this mine is reported to be of better quality than much of that available for steamships in Asiatic waters, containing less sulphur and ash, and a considerable tonnage has been mined already. The coals used at Vladivostok, about 100,000 tons annually, have come from Japan, Saghalien and Wales. The Russian naval vessels used Japanese coals mostly, about $600,000 worth annually. Several mines opened in the immediate vicinity of Vladivostok produce some coal that is lignitic and friable. The mines near New-Chang, connected with the Eastern Chinese Railway, proved disappointing, the Lu Sheng mines near Wa-fang-tien, on the Liaotung peninsula, were shut down because of the poor quality of the coal and the output of the mines at Yen-tai was small. The Chinese Eastern Railway in consequence was chiefly dependent on Japanese coal, though getting limited supplies from native workings in the interior. In Corea little coal mining has been done, though a few seams have been opened and crudely worked on a limited scale.

In the great coal fields of China some advance was reported, but the output increases slowly. In the province of Shan-si, noted for vast deposits of anthracite, the total production of anthracite and bituminous coal in 1903 may have been 50,000 tons, but there are no official figures. The Kaiping collieries, worked by the Chinese Engineering & Mining Company, in the province of Chile, produced and sold 700,000 tons. The Peking syndicate expected to start shipping anthracite to Tientsin in 1904. In the German protectorate of Kiao-Chou mines opened in 1903 produced 3,300 tons that year. The total Chinese imports of coal in 1903 were 1,402,701 tons, of which 804,050 tons came from Japan; the coke imports were 8,790 tons. Mines on the island of Formosa produced possibly 75,000 metric tons in 1902. In Dutch Borneo several mines were in operation during 1903. The Ombilien mines, worked by the State, produced about 200,000 metric tons. In Indo-China the Hongay anthracite mines produced 267,333 metric tons in 1903, and other mines produced lesser amounts.

The coal from the Gondwana beds of the Permian-Triassic series constitutes 95.5 per cent of the output of India, the remainder being coal of Cretaceous and Tertiary age. The total output of India in 1903 was 7,480,589 long tons; of this the railroads used 2,203,889 tons; 1,235,318 tons were exported to other Indian ports and 723,873 tons to ports outside of India. Over three-quarters of the total output, or 6,403,503 long tons in 1903, was mined in the province of Bengal, where are 262 mines, employing 73,900 persons. Nizam produced 362,733 tons, a decrease from 1902, caused by accidents closing several collieries and a lessened demand from the Colar gold field following the introduction of electricity generated by water power. The province of Assam in 1903 yielded 239,321 tons. There are great coal fields in Kashmir, but railways are needed to get the product to market, and the yield in 1903 was but 999 tons.

In Japan the growth of manufactures and the development of the merchant marine of late years have naturally created a much larger demand for coal. The most important coal fields are in Kiushu and Hokkaido. The principal coal fields in Kiushu are those of Miike and of Chikuho; the most important of Hokkaido are in Ishikari. The coals are bituminous; a little anthracite is mined in Kii and Higo. The two largest coal mining companies are the Mitsui and the Hokkaido. The former controls the Miike, Tagawa and Yamona mines, equipped with the best machinery, on the northwest coast of Kiushu and 35 to 40 miles from Nagasaki. These mines have a combined capacity of over 1,500,000 tons yearly. The Hokkaido company owns mines in Hokkaido, and also about 212 miles of railroads connecting the mines with the seaboard. The mines are the Sorachi, Yubari, Poronal and Iku Shunbetsu, and the amount of workable coal in sight is estimated at over 250,000,000 tons. The company also has an extensive coking plant at Oiwaki. The output of coal in 1903 was 859,883 tons. The total output of Japan in 1902 was 9,857,537 metric tons.

The Anthracite Coal Trade.

The great miners' strike in 1902 caused an actual coal famine in most communities where anthracite is largely used, and inevitably affected the market for months after its settlement. Consequently, it is not surprising that the output in 1903 surpassed all records, and that prices averaged higher than in 25 years. It is still too early to say what the ultimate effects of the 1902 strike will be, but one thing is evident, the market for coal during 1903 was not as good as might have been expected, considering the extraordinary conditions.

The wonder is not that the output was so large, but that it was not larger. How much the market was affected by the lessened demand from manufacturers during the last half of the year; or by the great slump in the market prices of bituminous, leading consumers who had changed from anthracite to bituminous during the strike to continue using the latter fuel; and how much the higher prices the companies exacted in return for the concessions made the miners have restricted buying, are questions which the course of trade during 1904 may answer. A few facts are, however, patent.

SHIPMENTS OF ANTHRACITE.

Road	1896.			1897.		1898.		1899.	
	Allotment.	Shipments.	Per Cent.	Shipments.	Per Cent.	Shipments.	Per Cent.	Shipments.	Per Cent.
Reading	20.50	9,019,533	20.9	8,395,411	20.2	8,219,814	19.6	9,685,568	20.3
Lehigh Valley	15.65	6,749,128	15.7	6,425,227	15.4	6,885,577	16.4	7,588,299	15.9
Central of New Jersey	11.70	4,999,003	11.6	4,730,860	11.4	4,626,386	11.0	5,392,550	11.3
Del., Lack. & W	13.35	5,627,533	13.0	5,690,684	13.7	5,795,540	13.9	6,372,837	13.4
Delaware & Hudson	9.60	4,152,273	9.6	3,921,665	9.4	3,891,246	9.3	4,132,573	8.7
Pennsylvania Railroad	11.40	4,752,120	11.1	4,767,536	11.5	4,801,349	11.5	5,162.141	10.8
Pennsylvania Coal Co	4.00	1,728,972	4.0	1,777,842	4.3	1,854,515	4.4	2,345,128	4.9
Erie	4.00	1,718,262	4.0	1,669,579	4.0	1,596,539	3.8	1,949,507	4.1
N.Y., Susq. & W	3.20	1,410,080	3.0	1,314,755	3.2	1,301,763	3.1	1,432,339	3.0
N. Y., Ont. & West	3.10	1,321,895	3.2	1,620,221	3.9	1,371,592	3.3	1,892,308	4.0
Del., Susq. & Schuylkill	3.50	1,698,684	3.9	1,324,086	3.2	1,555,429	3.7	1,692,014	3.6
Total	100.00	43,177,485	100.0	41,637,864	100.0	41,899,751	100.0	47,645,264	100.0

Road.	1900.		1901.		1902.		1903.	
	Tons.	Per Cent.	Tons.	Per Cent.	Tons.	Per Cent.	Tons.	Per Cent.
Reading	9,338,517	20.70	10,971,007	20.48	5,909,401	18.94	11,490,963	19.36
Lehigh Valley	6,909,444	15.32	8,310,343	15.51	4,631,535	14.84	9,737,160	16.40
Central of New Jersey	5,309,856	11.77	6,160,037	11.50	3,629,986	11.63	7,404,612	12.47
Del., Lack. & W	6,013,849	13.33	7,531,735	14.06	5,152,498	16.51	9,575,551	16.13
Delaware & Hudson	3,973,859	8.81	5,007,622	9.35	3,090,604	9.91	5,927,283	9.99
Pennsylvania Railroad	5,169,947	11.46	5,647,125	10.54	2,610,234	8.37	4,555,459	7.67
Pennsylvania Coal	2,090,153	4.64						
Erie	1,741,069	3.86	5,841,593	10.91	3,814,150	12.22	6,343,852	10.68
N. Y., Susq. & W.	1,333,848	2.95						
N. Y., Ont. & W	1,658,456	3.68	2,508,277	4.68	1,627,478	5.22	2,693,462	4.54
Del., Susq. & Schuylkill	1,568,488	3.48	1,590,862	2.97	735,004	2.36	1,634,489	2.76
Total	45,107,486	100.00	53,568,601	100.00	31,200,890	100.00	59,362,831	100.00

The shipments from the mines during 1903 were 59,362,831 long tons, compared with 31,200,890 tons in 1902 and 53,568,601 tons in 1901. Considering the generally prosperous condition of the country, and the steady increase in demand since the turn of the industrial tide in the winter of 1898-99, it is pretty clear that had there been no strike in 1902 the output in that year, as in 1903, would have been greater than in 1901. Since, as the short strike in 1900 did not materially affect the trade in 1901, and the demand that year, while abnormal in comparison with poor years, was not abnormal under prevailing industrial conditions, it is fair to assume that the shipments in 1903, had no strike occurred in 1902, would have been 5,000,000 tons larger; actually they were 6,000,000 tons larger. In short, the increased demand due to the strike was not as great as popularly imagined. This is also shown by the fact that tidewater supplies of coal were some 728,000 tons on December 30, 1903, practically nothing at the end of 1902 and 415,757 tons at the end of 1901.

At a meeting of representatives of the various anthracite railroads in January, 1896, arrangements were completed by which each road was allotted as an initial line a certain proportion of the total tonnage moved from the mines. This allotment was largely based on the average percentages carried by each road through a term of years previously, and was for the common good. Later, owing to developments in the industry and to clamor about its monopolization by railroads, statements that this agreement was no longer in force were made by interested parties. Regarding such assertions it is probably fair to say that certain roads have acted rather independently, that each strives hard to retain its share, and that none now tries as hard as it might to get business away from territorial competitors. During 1903 the percentages of the Lehigh Valley, Central of New Jersey, and Delaware, Lackawanna & Western increased, as compared with the averages of several preceding years, while those of the Pennsylvania railroad and of the Erie decreased.

Owing to the increased shipments of sizes smaller than No. 1 buckwheat, which sell at low prices, there is said to be an understanding among the producers that these sizes shall not be included as part of the allotments. The rate at which the proportion of small sizes shipped has increased during late years is one of the most impressive features of the anthracite trade. It has been caused by the small proportion of anthracite used in blast-furnace practice, by the low price of bituminous and by the necessity of the anthracite operator getting as much as he can out of his property in the face of higher mining costs and the competition of bituminous coal.

The proportionate production of the various sizes of anthracite in 1903 were as follows:

Size.	Tons.	Per Cent.
Steamboat sizes, lump and broken	7,179,720	12
Egg, stove and chestnut	31,112,120	50
Pea	8,576,340	14
Buckwheat, Nos. 1, 2, 3	12,494,651	24
Total	59,362,831	100

During the year there were few important changes in the ownership of great properties, except such as were indicated by the events of previous years, and were outlined in Vol. XI of THE MINERAL INDUSTRY. Consolidation and centralization of ownership of mines and railroads, which were such marked features of the last decade, however, seem likely to go but little farther. The most important change announced during the year was the transfer of a large block of Reading stock, including first preferred, second preferred and common, to the Baltimore & Ohio and the Lake Shore railroads, representing respectively Pennsylvania railroad and Vanderbilt interests, those roads receiving the stock so that any conflict with a clause of the Pennsylvania constitution which forbids a railroad acquiring an interest in a competing line, might be avoided. The total amount of Reading stock finally acquired by the two roads is believed to be about $68,000,000 in first preferred, second preferred and common, out of a total of $140,000,000.

This transfer virtually signalized the retirement of J. P. Morgan from the commanding position he had held, and showed that the Pennsylvania railroad had become the most powerful single interest in the anthracite trade.

Another event of the year was the retirement of the president of the Delaware & Hudson Company, Mr. Olyphant, after a long term of service with ensuing changes in the personnel and politics of various departments of the road.

The Anthracite Coal Strike Commission, appointed by President Roosevelt, in October, 1902, made its report in March. The commission virtually found that not one of the alleged grievances put forth by the United Mine Workers could be upheld by the evidence presented; still the Commission, probably in order that its report might be unanimous, gave contract miners a 10 per cent increase in pay, firemen an 8-hour day, and most other mine employees a nine instead of a 12-hour day. The awards are binding for three years, and any differences between operators and miners during that period are to be settled by a Board of Conciliation. A new sliding scale of wages was authorized, based on an average selling price of $4.50 for prepared sizes, f. o. b. New York Harbor as a minimum.

The proprietor of several sensational newspapers, to advertise himself, got the Interstate Commerce Commission to bring suit against the anthracite railroads, alleging discriminations in rates, excessive freight charges, also combination to control prices. The hearing in May elicited few facts not already matter of record, and the proceedings were cut short by a decision of Judge Lacombe to the effect that the Interstate Commerce Commission had no right to consider certain evidence which the plaintiff's attorney wished to introduce. The Commission appealed from this decision to the United States Supreme Court.

In 1903 each month from January to September inclusive established a new record of shipments, and the average for the nine months was nearly 5,232,000 tons monthly.

The f. o. b. New York harbor prices asked by the principal companies for free burning white ash coal were $4.75 for broken and $5 for egg, stove and chestnut in January, February and March; $4.25 for broken and $4.50 for egg, stove and chestnut in April; $4.35 and $4.60 in May; $4.45 and $4.70 in June; $4.55 and $4.80 in July; $4.65 and $4.90 in August, and $4.75 and $5 in September, October and November.

The shipments from the mines for the past four years compare as follows:

	1900.	1901.	1902.	1903.
	Tons.	Tons.	Tons.	Tons.
January.......	4,482,641	5,183,392	4,538,138	5,964,950
February......	3,188,180	4,123,594	3,741,253	5,070,608
March	3,133,896	4,964,359	3,848,767	5,211,450
April	3,364,482	3,715,295	4,924,830	5,044,998
May	3,833,097	4,693,562	1,708,892	5,156,449
June..........	4,676,580	4,755,748	92,203	5,436,497
July	3,599,729	3,698,814	250,079	5,377,495
August........	4,915,166	4,710,517	300,774	5,169,402
September.....	2,972,948	4,379,143	445,883	4,654,444
October	834,786	4,938,132	1,276.257	3,925,642
November.....	4,994,799	4,697,443	4,984,384	4,091,147
December	5,075,189	3,623,452	5,089,451	4,400,000
Totals	45,107,493	53,483,454	31,200,891	59,362,831

Trade by Months.—The year opened with anthracite in short supply everywhere and retail prices very high. The principal mining and transportation companies, however, refused to take advantage of the public need, and sold their coal for the stated price of $5 f. o. b. New York harbor for egg, stove and chestnut sizes, but many independent operators, who sold coal at the breakers to these companies under contracts that called for 65 per cent of the average tidewater selling price, objected to receiving 65 per cent of $5, claiming that the actual market price was $10 or more. To avoid litigation the companies voluntarily abrogated these contracts for three months, leaving the independents free to get any prices they could.

Early in January these retail prices prevailed for stove coal: Minneapolis, $10; Chicago, $11; Boston, $16; New York, $13, and Philadelphia, $12. In New England, the shortage of anthracite was the most acute ever known. Before February 1, owing to the extraordinary efforts of the principal coal mining companies, prices broke in the East, speculative coal f. o. b. New York harbor falling to $5.50 or less, and retail prices in the city to $7.50. A coincident decline in coastwise freight rates led to a heavy movement of coal to parts along Long Island Sound and beyond Cape Cod. In the West, however, receipts of coal by rail continued rather light, and prices showed little change. By March, as the result of record-breaking shipments from the mines in January and February, retail prices fell to $8, and less at Boston for egg, stove and nut sizes, and $6.25 at New York. In the West, however, as all supplies received by lake were gone, and all-rail receipts were still light, and coal sold at Minneapolis as high as $20 at retail, some independent operators soon regretted their abrogated contracts with the railroads, as the f. o. b. price at New York harbor fell to $5 per ton, and they had trouble in collecting money from speculators who bought at $10 and had to sell at a loss.

The Philadelphia & Reading announced in April that its basis prices for the ensuing year would be $4.75 for broken, and $5 a ton for egg, stove and nut sizes, f. o. b. New York harbor shipping ports, with graded monthly discounts. Other companies followed the Reading. The announcement of these prices led to a great rush of orders from eastern points, and also from the West, where docks were clean and supplies of anthracite completely exhausted. After the opening of navigation, shipments up the Lakes became very heavy, and the movement showed no falling off until late summer, when all dealers had their yards well filled. Retail prices, with the opening of navigation, fell to a parity with those at eastern points. During May, June and July wholesale trade in all anthracite territories continued very active, with premiums paid at many points for prompt deliveries. Retail buying, though it fell off with the advent of warm weather, remained unusually brisk, since more people than ever before took advantage of trade discounts to lay in supplies early.

By the opening of August demand had lost much of its urgency, and premiums for prompt delivery were no longer paid. The small steam sizes felt the slackening in demand first for several reasons. For one thing many concerns had shipped all sorts of stuff as coal during the winter, some of it being little better than culm, but consumers had to use it from necessity. As bituminous prices declined in the spring, consumers who could, stopped buying the small sizes of anthracite. By September 1 consumers and dealers at nearly all points had about all the coal they wanted, and there was no prospect of improvement until the advent of cold weather, so the companies began to talk of restricting output. The market was in such a state that a reduction of $1 per ton would probably have led to no great increase of orders. The first attempt at restriction was the closing of numerous washeries to prevent the accumulation of steam sizes at railroad storage points. Then the mining companies began to close breakers, which had been running steadily since the previous November and were in need of overhauling. During October many collieries were idle, though there was no concerted action toward restricting output. Some companies closed some collieries and ran others full time; other companies tried to run all their collieries, except such as were idle for repairs, four days a week. The market for anthracite continued quiet until the cold weather set in late in November; even then demand improved but slowly, and though December was a coal-burning month, demand showed no great increase until the last week of the year.

The Atlantic Seaboard Bituminous Trade.

During 1903 there was no change in the general policy of the chief railroads connecting the various producing districts with tide-water, these roads being the Pennsylvania and the Baltimore & Ohio, Chesapeake & Ohio and Norfolk & Western, all three virtually under the control of stockholders in the Pennsylvania company. The New York Central by its Beech creek line brought some coal to New York harbor, but was hardly an important factor in the seaboard trade. Producers during the year complained of discrimination in car allotments, etc., but these complaints were not as general as in 1902. The railroads were better supplied with cars and locomotives, and, owing to a falling demand, car-supply was generally sufficient for the needs of all producers during the last half of the year.

An important consolidation of the year was that of the Consolidated Coal Company, with mines in the Georges creek district in Maryland; the Fairmount Coal Company, with mines in the Fairmount region of West Virginia, and the Somerset Coal Company, owning a number of mines in Somerset county, Pa. The combination was virtually a stock exchanging deal backed by the Baltimore & Ohio railroad, and was intended to prevent the Wabash system, which has been actively at war with the Pennsylvania, from getting tonnage from any mines controlled by the three companies named.

Another important consolidation was in Pennsylvania, where the lands of the Webster Coal & Coke Company and several smaller concerns were taken over for operation by the Pennsylvania Coal & Coke Company, making the largest combination in the Clearfield region, controlling some 80,000 acres of land, chiefly in Cambria county, and destined to be an important factor in the seaboard trade. It ships over the Pennsylvania system chiefly.

The Wabash system made progress on its projected through line from the West to Baltimore by way of the West Virginia Central and the Western Maryland. Grading began on the line from Cherry Run to Cumberland to connect the Western Maryland and the West Virginia Central. In West Virginia the former stockholders of the Davis Coal & Coke Company organized the Davis Colliery Company, which is building the Coal & Coke Railroad, and developing a large tract.

Trade by Months.—Bituminous coal f. o. b. sold at Philadelphia for $9 per ton, or more than anthracite, at the opening of January, while many factories at seaboard points were closed waiting for cheaper fuel. Prices declined $1 per ton by January 10, when ordinary Clearfield sold at $7, f. o. b. New York harbor shipping port. This decline was due chiefly to large offerings of British coal for $4.50 and $5 per ton alongside at north Atlantic ports. By February 1 ordinary Clearfield had fallen to $5.25, f. o. b. New York harbor shipping port, though the tide-water receipts of domestic coal showed no increase, owing to slow transportations, short car supply, and heavy seizures of coal in transit by the railroads. By February 15 speculative prices had declined to $4 for Clearfield grades, and so much foreign coal was arriving at points beyond Cape Cod that there was little demand there for domestic coal. By February 20 the market was actually weak, and some of the lower grades of domestic coal were offered at $3, f. o. b. New York harbor, the decline being due to the heavy receipts from abroad, and to the unprecedented output of the steam sizes of anthracite. Car-supply at the mines had been 25 to 35 per cent of the demand since the beginning of the year.

With matters in this condition, producers, confronted by higher freight rates and higher miners' wages, determined to get higher prices, and by correspondence and formal discussions decided that the mine price on new contracts for the best grades of Clearfield should be $2.25 per ton, with lower grades in proportion, making the average mine price of Clearfield about $2 and the New York harbor, f. o. b. price about $3.35. This advance of 50 per cent over the 1903 prices was made against the advice of some of the best posted men in the trade, who felt that market conditions did not warrant such an advance and that slower buying and price cutting would follow. Though some contracts for special coals had been taken at prices ranging from $3.25 to $3.90, most consumers bought from hand to mouth, taking the offerings of small concerns who had to sell.

Coastwise Freight Rates.—Coastwise freight rates felt the extraordinary demand for coal at eastern points during the early winter, and the spring buying of anthracite. In January some charters from Philadelphia and New York to Boston were taken at $2.50 and $1.50 to Long Island sound points; but by January 20 rates from Philadelphia had fallen to $1.25 to Sound points and $1.90 to beyond Cape Cod; from New York harbor to Long Island sound $1, and $1.50 to Boston. February 20 they were 75c. from Philadelphia to Long Island sound, and $1.50 to Boston. February 20 they were 75c. from Philadelphia to Long Island sound points and $1.15@$1.30, according to size of vessel, to Boston, while from New York harbor quotations were 65@75c. to Long Island sound and $1@$1.25 to Boston, according to size of vessel. Barge rates about New York harbor fell from 35@40c. on January to 20c. on March 5. By the end of April, owing to heavy shipments of anthracite, vessels were scarce and rates were firm at these quotations: Philadelphia to Long Island sound ports, $1; Boston and Portland, $1.25; Portsmouth and Bath, $1.30; New York harbor to Long Island sound, 65@75c.; to points beyond Cape Cod, $1.15@$1.20. By June 1, with less urgency for anthracite, vessels were in better supply, and these quotations prevailed: Philadelphia to Providence, New Bedford and Long Island sound, 75@80c.; Boston and Portland, 95c.@$1; Portsmouth and Bath, $1; Bangor, $1.25; from New York, 70@75c. to Sound ports, and $1@$1.15 to Boston and Portland. After this rates changed but little for some time, and then slowly declined. The year closed with these quotations prevailing: Philadelphia to Providence, New Bedford and Long Island sound, 60c.; Boston and Portland, 70c.; Portsmouth, 75c.; and from New York harbor to Long Island sound, 50c.; Boston and Portland, 60@65c.

COPPER.

BY D. H. NEWLAND.

The production of copper in the United States during 1903 amounted to 689,045,796 lb., the largest output ever recorded, and an increase of approximately 43,000,000 lb., or 7 per cent over the total for the previous year. Most of the increase was due to the Lake Superior and Arizona districts where there have been many important developments recently, leading to the opening of several large mines. In the Butte district the industry was seriously handicapped by litigation between the Amalgamated and United Copper companies, and the output showed a falling off. California also failed to maintain the record for 1902, owing principally to labor troubles. The Bingham district of Utah continued to advance, and this State now ranks fourth as a copper producer, displacing California for the first time.

COPPER PRODUCTION IN THE UNITED STATES. (POUNDS OF FINE COPPER.)

States.	1900.		1901.		1902.		1903.	
	Pounds.	Long Tons.	Pounds.	Long Tons.	Pounds.	Long Tons.	Pounds.	Long Tons.
Arizona	115,403,846	51,520	126,183,744	56,332	119,841,285	53,501	153,591,417	68,568
California	29,639,987	13,232	33,667,456	15,030	25,038,724	11,178	19,113,861	8,533
Colorado	7,826,949	3,494	7,872,529	3,515	8,463,938	3,779	7,809,920	3,487
Michigan	144,227,340	64,387	155,511,513	69,425	170,194,996	75,979	192,299,485	85,848
Montana	254,460,713	113,599	229,870,415	102,621	266,500,000	118,973	245,000,000	109,375
Utah	18,504,726	8,261	20,116,979	8,981	23,939,901	10,687	37,800,000	16,875
Eastern and Southern States	6,918,122	3,088	6,860,039	3,063	13,599,097	6,071	16,500,000	7,367
All others	12,536,850	5,597	17,360,537	7,750	9,154,753	4,087	10,650,000	4,754
Copper in sulphate (*b*)	11,313,962	5,051	11,730,000	5,232	9,154,753	4,087	6,281,113	2,804
Total domestic production	600,832,505	268,229	609,173,212	271,949	645,887,447	288,342	689,045,796	307,610
Stock January 1	88,722,559	39,608	93,050,230	41,541	209,587,698	93,566	162,935,439	72,739
Imports, bars, ingots, old, and ores (*a*)	103,805,793	46,342	176,472,369	78,782	161,551,040	72,121	167,161,720	74,626
Total supply	793,360,857	354,179	878,695,811	392,275	1,017,026,185	454,029	1,019,142,955	454,975
Deduct exports	352,731,143	157,469	227,194,184	101,426	376,298,726	167,991	332,282,194	148,340
Deduct consumption	347,579,484	155,169	440,913,929	196,837	477,792,000	213,300	501,819,081	224,027
Stock December 31	93,050,230	41,541	209,587,698	94,009	162,935,439	72,738	185,041,680	82,608

(*a*) This includes copper imported in low-grade Spanish and other pyrites, chiefly for sulphur, and the copper imported from Canada in copper-nickel matte, in which the nickel is the metal of chief value; also the copper in certain gold and silver ores. These items, until 1898, did not appear in the United States statistics of imports. (*b*) Including only the copper in sulphate obtained as a by-product and by leaching copper ores.

The year was a fairly prosperous one for the industry, although the influence of the violent reaction of 1901 was still felt in the market. The price for lake copper at New York averaged 13.417c., as compared with 11.887c. in 1902 and 16.55c. in 1901. The average quotations for electrolytic copper at New York were 13.235c., against 11.626c. in 1902 and 16.11c. in 1901. There was a notable expansion in the domestic consumption of copper, especially during the early months of the year, and the unusual demand about counterbalanced the decrease in the volume of the exports. The stock of copper on hand at the close of 1903 was approximately 185,041,680 lb., as compared with 162,935,439 lb. in the previous year.

The output of copper sulphate in 1903 amounted to 43,124,454 lb., as compared with 48,763,538 lb. in 1902. Of these totals respectively 25,124,454 lb. in 1903 and 35,879,212 lb. in 1902 were recovered as by-product.

Review of Copper Mining in the United States During 1903.

Alaska.—Much interest is being shown in the development of the copper deposits along the Alaskan coast, and, although some time must elapse before the mines can be properly opened and metallurgical plants installed, the prospects for this region seem promising. In the Ketchikan district, adjacent to Dixon entrance, mining has already begun on a small scale. The ores of this district include chalcopyrite and bornite with carbonates on the surface, and usually carry some gold. On the west coast of Prince of Wales island the Alaska Copper Company is developing a group of properties and has a smelter under construction. Another smelter is being installed on the eastern side of the island, which will treat ores from the Mamic mine. The Copper River country has received some attention during the year, but exploration is retarded by the difficulties of transport. The deposits are situated near the southern slope of the Wrangle mountains, some 200 miles by trail from the coast. In the Prince William Sound region, the outlook for the immediate future is more favorable. The ore-bodies are situated close to tidewater and can be worked without any great outlay of capital.

Arizona.—The production of copper in 1903 was the largest ever recorded in the Territory, showing an increase of approximately 34,000,000 lb., or 28 per cent over the output of the previous year. The gain has been due directly to the operations of the Shannon company in the Clifton district and the Calumet & Arizona company in the Bisbee district; but throughout the Territory there has been unprecedented progress in the industry, which will be reflected in the production of the next two or three years. Nearly all of the old companies have made extensive improvements in mining and metallurgical equipment, placing them in position to increase their output and at the same time to effect important economies. Several new properties are under development and will soon enter upon the producing stage. As a result of the great activity, the output of Arizona may be expected to expand rapidly for some time to come. A full account of the year's developments in copper mining will be found in the review by James Douglas, elsewhere in this volume.

The Arizona Copper Company, Ltd., during the half year ending March 31, 1904, smelted 49,645 tons of ore and concentrate and 1,491,441 lb. of precipitate, producing 14,756,441 lb. of copper. The quantity of ore concentrated amounted to 231,552 tons, of which 50,436 tons were obtained from the Metcalf group of mines, 148,782 tons from the Humboldt tunnel workings, and 32,334 tons from the Coronado mine. The acid plant produced 1,826 tons of sulphuric acid, which was consumed in the leaching plant. Net profits of £119,379 were earned from the mining operations and £39,842 from the railroad. The dividend distribution of 1s. 5d. per share called for £107,659, leaving a surplus of £28,792. An electric haulage system has been adopted in the Humboldt tunnel, and it is to be extended as necessity arises.

During 1903 the Calumet & Arizona Mining Company, in the Warren district, produced 12,768 short tons of copper from 145,916 tons of ore, an average recovery of 8.88 per cent. A dividend of $2 per share (or $400,000) was paid, and there remained a net balance of $1,441,474 above all liabilities at the close of the year.

COPPER PRODUCTION IN ARIZONA. (*a*) (POUNDS OF FINE COPPER.)

Mines.	1899.	1900.	1901.	1902.	1903.
Arizona Copper Co	19,072,709	19,697,086	20,535,800	30,821,842	30,228,000
Calumet & Arizona	....	....	....	2,066,647	25,536,000
Copper Queen	36,901,684	34,382,309	39,781,333	35,831,755	36,939,800
Detroit	13,906,253	10,749,258	17,535,000	18,721,411	16,558,232
Old Dominion	6,300,000	7,155,000	10,094,300	7,992,550	7,479,721
Shannon	....	....	....	....	6,578,117
United Verde	43,995,932	39,970,193	34,520,695	19,407,080	23,771,547
United Globe	4,451,180	*Nil.*	830,100	*Nil.*	*Nil.*
Other mines	*e* 750,000	*e* 3,450,000	*e* 2,886,516	*e* 5,000,000	6,500,000
Totals	125,377,758	115,403,846	126,183,744	119,841,285	153,591,417

(*a*) Reported by producers direct to THE MINERAL INDUSTRY. (*e*) Estimated.

California.—The production of copper in 1903 was 19,113,861 lb., showing a large falling off from the previous year. Of the total given, Shasta county contributed 16,453,409 lb., and Calaveras county 2,246,675 lb. The reduced output in 1903 was due to labor troubles, which resulted in a temporary suspension of operations by some of the largest mines. The Mountain Copper Company, which is the largest producer in the State, mined 118,973 tons of ore in 1903, and smelted 124,678 tons. From sales of copper and other sources gross profits of £152,730 were realized, from which the net balance amounted to £143,366. No dividends were declared. Two furnaces have been added to the smelter, making five in all. A sulphuric acid plant will be added to the works. In the Bully Hill district, the Idaho, Iowa and Columbia mines have been sold to the company owning the Bully Hill smelter. A new 175-ton furnace has been added to the Bully Hill plant. Several properties near Taylorsville, Pluma county, are under development, and it is planned to erect a smelter. In Del Norte county, near Smith river, the Cleopatra Copper Company is engaged in developing a copper deposit which is reported to carry high values. The Broda Mining & Smelting Company has acquired the Keystone group at Old Diggings, and is considering the erection of a smelting plant.

Colorado.—The output of copper in 1903, according to E. L. White, commissioner of mines, was 7,809,920 lb. Lake and San Juan counties were the largest producers.

Idaho.—In the Seven Devils district little mining was done during 1903, and only a small quantity of ore was shipped. One of the largest groups of mines has been bonded by outside capitalists. The Ladd Metals Company at Mineral started its smelter in the latter part of the year, and made shipments of high-grade matte. The company is said to have large deposits of sulphide ore. At Mackay the White Knob Copper Company has erected a smelter of two 350-ton furnaces. One furnace was placed in commission in October, turning out 58 per cent copper matte with important gold and silver values. The company's mine is situated 2,000 ft. above the smelter on a spur of White Knob. The ore consists of oxide and carbonates, and carries from two to four per cent copper, and $2 in gold and silver per ton.

Michigan.—Another important increase was registered by the Lake Superior mines in 1903, the output being approximately 13 per cent larger than that of the previous year. The expansion in production has been due almost entirely to the new mines, as the older properties, with the exception of the Osceola, did not show any material increases. The output of the Calumet & Hecla was less by nearly 5,000,000 lb. than in 1902. It is expected that the figures for the present year will show a further gain of probably not less than 10,000,000 lb. The production of all mines during the past five years has been as follows:

COPPER PRODUCTION IN MICHIGAN. (POUNDS OF FINE COPPER.)

Mines.	1899.	1900.	1901.	1902.	1903.
Adventure	....	....	....	606,211	2,182,608
Arcadian	500,000	*e* 800,000	*e* 1,000,000	*e* 500,000	*Nil.*
Atlantic	4,675,882	4,930,149	4,666,889	4,949,368	5,505,598
Baltic	603,570	1,735,060	2,641,432	6,284,819	10,580,997
Calumet and Hecla	98,002,137	81,403,041	82,519,676	81,248,739	76,490,869
Champion	....	....	....	4,165,784	10,564,147
Franklin	1,230,000	3,663,710	3,757,419	5,259,140	5,309,030
Isle Royale	*Nil.*	*Nil.*	2,171,955	3,569,748	3,134,601
Mass.	61,000	*Nil.*	*e* 800,000	2,345,805	2,576,447
Mohawk	....	....	160,897	226,824	6,284,327
Osceola Consolidated	10,950,000	11,200,000	13,723,571	13,416,398	16,059,636
Quincy	14,301,182	14,116,551	20,540,720	18,988,491	18,498,288
Tamarack	17,750,000	18,400,000	18,000,852	15,961,528	15,286,093
Trimountain	....	....	....	5,730,807	9,237,051
Winona	....	....	....	101,188	1,036,944
Wolverine	4,789,015	4,778,829	4,946,126	6,473,181	8,999,318
All other mines	2,983,000	3,200,000	577,931	366,965	553,531
Totals	155,845,786	144,227,340	155,507,465	170,194,996	192,299,485

The Calumet & Hecla Mining Company, during the year ending April 30, 1904, produced 38,310 short tons of copper, as compared with 38,316 tons in the corresponding period of the previous year. Four dividends of $10 each, amounting in all to $4,000,000, were distributed among the shareholders. In the president's report it is stated that the new openings on the conglomerate belt in the vicinity of the Red Jacket shaft continued to prove unsatisfactory, the rock carrying 15 per cent less in copper than in former years. Exploration in No. 12 Hecla shaft has been abandoned, and work will be discontinued in No. 11 as soon as the pillars are removed. Three shafts were started in the amygdaloid lode which, so far as encountered, contained a fair percentage of copper.

The Quincy Mining Company reported an output of 18,498,288 lb. of copper from 958,935 tons of rock stamped, or an average of 19.29 lb. copper per ton of ore. From sales of copper and interest there was received the sum of $2,465,156, while the total expenses amounted to $1,926,230. Dividends of $5.50 per share, or $550,000, were paid during the year. The most important additions to the equipment of the mine were the construction of storage bins and the installation of an electric haulage system. Each shaft is now in position to handle 1,200 tons of ore per day. The usual amount of development work was done during the year with fair results.

According to its annual report the Osceola Consolidated Mining Company produced 16,059,636 lb. of copper in 1903. The quantity of rock stamped was 924,400 tons, showing an average recovery of 17.4 lb. against 16 lb. in the previous year. From sales of copper and other sources the sum of $2,105,924 was received, out of which the net profits amounted to $453,735. A dividend of $1 per share, or $96,150, was paid, and the balance carried forward to the current year. Owing to the failure to find any good ore, development work was stopped in the Tamarack Junior, and the underground equipment has been removed and transferred to the other workings. The North Kearsarge and South Kearsarge continued to show satisfactory returns.

The Tamarack Mining Company during 1903 treated 657,920 tons of ore in its mill, producing 15,286,093 lb. of copper. The average recovery was 1.16 per cent, as compared with 1.21 per cent in 1902. The total receipts for the year amounted to $2,042,223, and the expenses were $1,757,158, leaving net profits of $285,065, from which a dividend of $1.50 per share (or $90,000) was paid, and the remainder carried forward to 1904. Development work in No. 5 shaft showed a large area of ground averaging above the normal in grade, and indications lead to the belief that a large mine will be opened. The shaft is being equipped with hoisting machinery.

The Mohawk Mining Company in 1903 reported an output of 6,284,327 lb. of copper from 288,441 tons of rock stamped, a yield of 21.79 lb. per ton. The net earnings from the gross income of $839,681 amounted to $287,482.

The Atlantic Mining Company produced 5,505,598 lb. of copper in 1903. The grade of rock crushed showed some improvement, the average yield being 12.76 lb. per ton, against 11.09 lb. in the previous year. From sales of copper the receipts were $722,386, and the net income was $125,342. The company sold a portion of its surface rights on Portage Lake to the Michigan Smelting Company.

The Wolverine Copper Mining Company produced 8,999,318 lb. of copper in 1903. For the fiscal year ending June 30, 1904, the company's report showed gross earnings of $1,192,425, and a net income of $557,240.

The Isle Royale Copper Company during 1903 made an output of 3,569,748 lb. of copper from 263,672 tons of ore. The income amounted to $444,595 and the earnings were $73,281.

The Michigan Smelting Company, formed by the Wolverine, Champion, Trimountain, Baltic, Mohawk and Atlantic companies, began the erection of a smelter on Portage Lake. It will be run as a co-operative smelter, treating the mineral produced by the companies named. It is expected to be in operation early in 1905.

Montana.—The year's developments in copper mining are reviewed by William A. Akers elsewhere in this volume. The production of copper by Montana mines in 1903 amounted approximately to 245,000,000 lb., showing a decrease of 21,500,000 lb. from the output in the previous year. Owing to the policy adopted by some of the larger companies in withholding information as to their operations, the collection of statistics for this State is attended with unusual difficulty.

The following statement, showing the financial results obtained by the leading mines in the Butte district, has been prepared from reports submitted by the companies to the board of county assessors. The statistics are for the year ending June 1, 1904.

STATISTICS OF BUTTE COPPER MINES.

Company.	Tons Treated.	Gross Product.	Expenses.	Net Earnings.
Anaconda	983,001	$10,761,473	9,501,597	$1,259,876
Boston & Montana	988,866	12,720,282	8,145,784	4,574,498
Butte & Boston	202,286	1,576,622	1,479,769	96,853
W. A. Clark	278,776	2,428,126	2,183,332	244,794
Colorado S. & M. Co	206,035	1,016,597	941,665	74,832
Montana Ore P. Co.	224,080	1,694,045	1,264,932	429,113
Minnie Healey	119,817	750,054	768,027	17,973
Johnstown	15,865	273,830	283,717	90,113
Parrot	476,581	1,270,627	1,036,662	233,965
Speculator	90,352	762,528	528,790	233,738

New Jersey.—The mine of the Arlington Copper Company near Arlington was offered for sale in September, 1903. The company erected an expensive plant to treat the low-grade ore, but the process proved unsuccessful.

New Mexico.—In the Santa Rita district activity in mining was restricted somewhat by the low price of copper. The Burro Mountain smelter has been removed to Silver City, where also the Chatham Copper Company has erected a smelting plant. The Michigan & New Mexico Copper Company and the Mogollon Gold & Copper Company operated their mines during the year, and it is announced that the Santa Fe Gold & Copper Company will resume work.

Oregon.—The Waldo Smelting & Refining Company is reported to have opened a rich vein of copper ore in the Waldo district, but its exploitation will be postponed until better transport facilities are secured.

South Dakota.—The Copper Butte Mining Company is working a deposit of copper pyrite near Custer, and shipping the ore to the National smelter at Rapid City. The Central Black Hills Copper Company, which passed into new hands during the year, has erected a lixiviation plant for treating its ores, which average about 3 per cent copper.

Tennessee.—The production of copper in 1903 amounted to 13,668,389 lb., all of which was made by the two companies operating in the Ducktown district, the Tennessee Copper Company and the Ducktown Sulphur Copper & Iron Company. The former company owns the Burra Burra, London and Polk County mines, and the latter the Mary and Calloway mines. The Ducktown company suspended mining operations for a part of the year in order to reduce the stock of ore on hand and to make changes in its smelting plant. The practice of roasting the ore previous to charging into the furnace has been superseded by pyrite smelting, and this plan is to be adopted also at the Tennessee Copper Company's plant. During 1903 this company produced 287,465 tons of ore, of which 284,202 tons were smelted, yielding 10,690,389 lb. of copper. The average extraction was 37.6 lb. per ton, or a little less than 2 per cent. From sales of copper and other sources there were realized gross profits of $500,420. The net profits were $417,565. Two dividends, each of $218,750, were paid during the year. The reserves on January 1, 1904, were estimated at 2,775,000 tons. It is expected that the product for 1904 will be about 14,000,000 lb.

Utah.—The Bingham district was very active during 1903. At the Highland Boy, owned by the Utah Consolidated Mines Company, the output amounted to about 13,250,000 lb. of copper. Additions are to be made to the smelter which will materially add to its capacity. The Bingham Consolidated Mining & Smelting Company ran its smelter steadily, a portion of the ore being purchased from the mines at Tintic, and the remainder taken from the Commercial mine owned by the company. The output for the year exceeded 8,000,000 lb. The Eagle & Blue Hill mine in the Tintic district has been added to the company's properties. The smelter of the United States Mining Company, consisting of three furnaces, turned out about 8,000,000 lb. of copper. The Tintic Mining & Development Company has completed a 250-ton smelter near Bingham. Further details relating to the progress of copper mining in Utah will be found in the review by James W. Neill, elsewhere in this volume.

Wyoming.—The production of copper in 1903 was 947,106 lb. A full review of the progress of copper mining during the year will be found in the article contributed by Henry C. Beeler, elsewhere in this volume.

Copper Mining in Foreign Countries During 1903.

Australia.—The output of copper in New South Wales in 1903 amounted to 5,631 long tons of metal and 3,569 long tons of ore and matte. These totals do not include the product of ores imported into the State for treatment. The largest mines are situated in the Cobar and Burrago districts. The Great Cobar Copper Company operated its new 300-ton furnace throughout the year, and has made arrangements to erect a second furnace which will increase the smelting capacity to 4,000 tons per week. It is said that the results obtained so far have been highly satisfactory. Development work was carried on by the Queen Bee and Cobar Chesney companies in the Cobar district. The Lloyd Copper Company treated 65,397 tons of ore during 1903, producing 1,825 tons of copper. In the Nymagee district the Crowl Creek Mining Company has installed four reverberatory furnaces and is preparing for an active campaign.

The output of copper in Tasmania, during the year ending June 30, 1903, was as follows: pig copper, 6,213 long tons; copper matte, 6,227 long tons; ore, 1,927 long tons. The most important event of the year has been the amalgamation of the Mount Lyell Mining & Railway Company, Ltd., and the North Mount Lyell Copper Mining Company, Ltd., the new company taking the former title. Under the consolidation all the ore from the North Mount Lyell mine is to be treated at the company's reduction works at Queenstown. The first report of the company for the period, August 11, 1903, to March 31, 1904, states that under the new arrangement it has been possible to effect important economies. During the period mentioned 240,852 tons of ore were treated, producing 5,005 tons of blister copper, which contained 4,914 tons of fine copper, 510,906 oz. silver and 13,193 oz. gold. The average costs per ton of ore were: Mining, 5s. 1.56d.; smelting, 8s. 5.54d.; converting, 1s. 6.06d. The ore reserves in the Mount Lyell mine were estimated at 1,613,918 tons, assaying 0.66 per cent copper, 190 oz. silver and 0.049 oz. gold. In the North Mount Lyell mine the reserves were 170,494 tons, averaging 6.25 per cent copper, 225 oz. silver and 0.005 oz. gold.

Western Australia produced 20,526 long tons of copper ore in 1903, against 2,262 tons in the preceding year. A discovery of rich ore was reported by the Arrino Proprietary Copper Company in its mines 200 miles north of Perth. The company will erect a smelter at Dongarra. In the Phillips River district there was marked activity in mining, owing to the assistance given the small operators by the government.

In South Australia the copper mines on Yorke Peninsula produced 5,027 long tons of copper from 164,866 tons of ore. This represents the output of the Wallaroo & Moonta mines; in addition the Hamley mine turned out 1,066 tons of concentrate, carrying 17 per cent copper. During the year, the Paramatta and Yetta mines have been worked by a French company, and a smelter and other machinery erected on the property. At the Lynda mine, near Mount Lyndhurst, work has been carried on energetically and a satisfactory quantity of ore raised. Developments at Mount Rose have proved so encouraging that a new smelter will be installed. The Tasmanian Copper Company, Ltd., reopened the old Blinman mine; also the Prince Alfred, near Mattawarrangala, has been worked. Good ore has been obtained from the Yudnamutana properties, and generally throughout the north country fair grade ore has been mined by the small holders. The deposits of low-grade ore at Mount Gunson, northwest of Port Augusta, remained unworked, owing chiefly to difficulties of transport and concentration.

In Queensland, copper mining made good progress during 1903. The production of the State amounted to 4,916 long tons, against 3,784 long tons in the previous year. The New Chillagoe Railway & Mines, Ltd., had one furnace in operation which produced 2,121 tons of copper, the ores being obtained from the company's mines and by purchase. The Queensland Copper Company smelted 10,597 tons of ore, for 1,865 tons copper, 70,768 oz. silver and 1,309 oz. gold. A second furnace has been added to the smelting plant, and a concentrator has been installed for treating the silicious ores. The company has opened a good lode in its New Moonta mine, and the latter will be connected by tramway with the Mount Perry Railroad.

Canada.—The production of copper in 1903, according to official sources, was 43,281,158 lb., as compared with 38,804,259 lb. in the previous year. Of the total in 1903 British Columbia supplied 34,359,921 lb., and the remainder came from the eastern provinces, principally from the nickel-copper district of Ontario. Reference should be made to the reviews of S. S. Fowler and Thomas W. Gibson for details as to the year's developments in copper mining in these sections.

The Eustis and Nichols mines at Capelton, Quebec, were worked during 1903, yielding 23,644 long tons of ore, of which 14,770 tons were shipped to the United States, and 8,874 tons were treated for sulphuric acid at Capleton. An electric power plant is being installed at the Eustis mine. Plans were formulated during 1903 for the erection of a smelter to treat the ore from the various small mines in the Sherbrooke region.

In Nova Scotia development work has been carried on at several localities, but as yet there has been no active mining. The Colonial Copper Company has installed a large plant on its property near Cape d'Or, comprising air compressors, drills and other machinery, and will erect a concentrator. In the Cheticamp district several deposits are being explored with promising results.

Chile.—There has been little advance made in the copper mining industry during the last quarter of a century, the output being steadily maintained around 25,000 tons annually. This rate of production, however, is far from representative of the country's resources, as it is well known that Chile is very richly endowed as regards the wide distribution and extent of its copper deposits. The chief drawbacks to mining have been the lack of railroads and the high cost of fuel. With the construction of the Andean railway, which will give access to the contiguous districts from both the Pacific and Argentine sides of the Andes, and the extension of the Taltal railroad to Atacama, it is expected that the industry will show greater progress. During 1903, a company was organized under the title of Copaquire Copper Sulphate Company, Ltd., to work the deposits of natural copper sulphate occurring near Huatacondo, province of Tarapaca. According to Edward Walker,[1] the sul-

THE WORLD'S COPPER PRODUCTION, 1899-1903. (*a*).

Countries.	1900.		1901.		1902.		1903.	
	Tons of 2240 Lb.	Metric Tons.	Tons of 2240 Lb.	Metric Tons.	Tons of 2240 Lb.	Metric Tons.	Tons of 2240 Lb.	Metric Tons.
Argentina	75	76	780	793	240	244	135	137
Australasia	23,000	23,368	30,875	31,371	28,640	29,098	29,000	29,464
Austria-Hungary	1,355	1,377	1,335	1,356	1,600	1,626	1,385	1,407
Bolivia	2,100	2,134	2,000	2,032	2,000	2,032	2,000	2,032
Canada	8,459	8,595	18,282	18,575	17,485	17,765	19,322	19,631
Cape of Good Hope: Cape Co.	4,420	4,491	4,000	4,064	2,750	2,794	4,630	4,704
Cape of Good Hope: Namaqua	2,300	2,337	2,400	2,439	1,700	1,727	600	610
Chile	25,604	26,016	30,805	31,299	28,930	29,393	30,930	31,424
Germany—Total	20,310	20,635	21,720	22,069	21,605	21,951	21,205	21,544
(Mansfeld)	(18,390)	(18,684)	(18,780)	(19,082)	(18,750)	(19,050)	(18,975)	(19,279)
Italy	2,753	2,797	3,000	3,048	3,370	3,424	3,100	3,150
Japan	27,840	28,285	27,475	27,916	29,775	30,251	31,360	31,861
Mexico—Total	22,119	22,473	33,813	33,943	35,785	36,357	45,315	46,040
(Boleo)	(11,119)	(11,297)	(10,783)	(10,956)	(10,785)	(10,958)	(10,315)	(10,480)
Newfoundland	2,283	2,929	2,756	2,800	2,860	2,906	2,710	2,753
Norway	3,935	3,998	3,375	3,429	4,565	4,638	5,915	6,010
Peru	8,220	8,352	9,520	9,673	7,580	7,701	7,800	7,925
Russia	8,000	8,128	8,000	8,129	8,675	8,814	10,320	10,485
Spain-Portugal—Total	52,872	53,718	53,621	54,482	49,790	50,587	49,740	50,536
Rio Tinto	35,732	36,304	35,348	35,916	34,480	35,032	35,810	36,382
Tharsis	7,965	8,092	7,427	7,546	6,710	6,817	6,320	6,421
Mason & Barry	3,460	3,515	3,729	3,789	3,330	3,383	2,430	2,469
Sevilla	1,460	1,483	1,292	1,313	1,545	1,570	1,105	1,123
Sweden	450	457	450	457	455	462	455	462
Turkey	2,304	2,341	1,639	1,665	1,100	1,118	1,400	1,422
United Kingdom	765	777	532	541	480	488	500	508
United States	268,229	272,536	271,949	276,300	288,342	292,955	307,610	312,532
Totals	485,634	494,422	528,327	537,381	537,727	546,331	575,432	582,243

(*a*) The figures in this table are taken from the annual metal circular of Henry R. Merton & Co., except where returns have been received by THE MINERAL INDUSTRY direct from official sources.

phate is found in hydrated form in thin, irregular veins which are disseminated over a large area. Analyses show that the material varies considerably in composition, but an average sample gave 12.27 per cent of copper sulphate, 1.53 per cent of copper carbonate and 0.39 per cent of copper sulphide, making in all 4.44 per cent of metallic copper. It is proposed to extend the Antofogasta and Bolivia railroad to the mines.

Germany.—According to the official government reports, the output of copper ores in 1903 was 772,695 metric tons, while the production of metal amounted to 31,214 tons. In the latter total is included, however, the copper made from imported ores and matte, so that the actual domestic production is considerably less than the figure given. The largest copper mines in Germany are owned by the Mansfelder Kupferschieferbauende Gewerkschaft, and are situated in the Mansfeld district of Prussia. During the year 1903, the

[1] THE ENGINEERING AND MINING JOURNAL, May 9, 1904.

company smelted 685,880 tons of ore for a yield of 19,258 metric tons of copper and 97,358 kg. silver.

Japan.—According to a recent British consular report, the exports of copper in 1903 were 27,400 long tons, against 20,284 tons in the previous year. China, the United Kingdom and the Straits Settlements are the largest consumers of Japanese copper.

Mexico.—There has been a remarkable advance in copper mining during the past four years, and the annual output has more than doubled in that time. Should the present rate of increase be maintained the production next year will exceed that of Spain, placing the country in second position among the copper producers of the world. The most important developments have been made in the State of Sonora, due to the erection of the smelting plants at Nacosari and La Cananea, and the completion of the smelters at Douglas, Arizona, just across the Mexican border. Copper mines are being worked also in Durango, Zacatecas, Aguascalientes, Michoacan, Pueblo, Guerrero and Chihuahua, while a good deal of copper is obtained as a secondary product in gold and silver mining. The Boleo Copper Company in Lower California made its usual output during 1903.

The Greene Consolidated Copper Company, which owns the mines at La Cananea, produced 43,228,120 lb. of copper bullion during the year ending July 31, 1903. The total receipts of the company were $3,783,961, while the total costs amounted to $2,963,496, leaving a profit balance of $820,465. The Boleo Copper Company during 1903 produced 10,480 tons of copper. The quantity of ore mined was 230,490 metric tons, and the average recovery of copper 4.56 per cent. The financial statement shows profits for the year of 5,829,449 fr., from which dividends amounting to 2,500,008 fr. were distributed.

For further information regarding the copper mining industry in Mexico reference should be made to the review by James W. Malcolmson, later in this volume.

Newfoundland.—The output of copper ore in 1903 amounted to 87,790 tons, valued at $343,050, the metallic contents of which were estimated to be 2,710 tons. Of the production the Tilt Cove mines furnished 75,676 tons, the Terra Nova mine 11,000 tons, and the York Harbor mine 1,114 tons. As in previous years the ore was exported to the United States and England, where it is smelted at the works of the Nichols Chemical Company and the Cape Copper Company. In the report of the latter company for the year ending August 31, 1903, it is stated that the income from operations at Tilt Cove was £68,103, and the net profits £20,533. The output of the East mine was 45,606 tons, assaying 3.45 per cent copper; of the South lode 16,627 tons, assaying 3.75 per cent; of the North lode, 1,063 tons, assaying 2.63 per cent. The shipments for the year amounted to 73,615 tons, of which 25,743 tons went to Garston and 39,719 tons were sent to New York.

Norway.—The production of copper during 1903, including the metallic contents of ore exported, amounted to 6,010 metric tons. The largest mine in this country is the Sulitjelma, which is credited with an output of 60,434 tons of ore averaging from 3.75 to 4.5 per cent copper. The company owning this mine has taken over the Alten property, where it is installing a new concentrator. The output of the smelter in 1903 was 640 tons bessemer copper. At the Röros mine 740 tons copper and 13,808 tons pyrite were produced. The mines at Kjoli near Röros have been taken over by an English company, and active development will begin in the near future.

Peru.—The copper mining industry has expanded rapidly in recent years, and there is every prospect that the production will continue to increase for some time to come. One of the leading enterprises, although not yet actively engaged in mining, is the Haggin syndicate, which is operating in the Cerro de Pasco district. This company has acquired a large group of properties on which it is reported that several million tons of ore, carrying 10 per cent copper as a minimum, have already been opened. A smelting plant is under construction, and the mines are to be connected by railroad with the port of Oroyo. A Peruvian company has erected a smelter at Huaraucaca which is now under successful operation. Mining is being done also in the department of Ica and the province of Yauli. Deposits are known to occur in many other regions, but until the advent of better transport facilities they cannot be worked economically.

Portugal.—The principal copper producer in this country is the San Domingos mine, owned by Mason & Barry, Ltd. The output in 1903 was 217,207 tons of ore, while the shipments amounted to 349,380 tons, of which 341,631 tons were sold for the sulphur value alone. The production of copper was 2,430 long tons. The company's statement for the year shows net profits of £85,056, from which dividends of 7s. per share were paid and a balance of £23,078 carried forward to the current year. The stocks of ore and precipitate on hand December 31, 1903, were valued at £96,099.

Russia.—The production of copper in 1903 amounted to 10,485 metric tons, representing about half of the consumption of the metal in the country. The most important mining district is in Transcaucasia which furnishes fully 50 per cent of the output. The Kedabek mine, near Elizavetpol, owned by the firm of Siemens, of Berlin, produced 3,400,000 lb. in 1902, and the mine at Alawerdi in the district of Bortschalo, which is operated by a French company, turned out about 2,000,000 lb. in the same year. There are mines also in the Urals and in central Siberia.

Santo Domingo.—Copper mining has been recently started in the San Cristobal district, where a small furnace is in operation. The copper matte is shipped to the United States for refining.

Servia.—A small quantity of copper ore is mined near Maidanpek, and there are deposits in the vicinity of Bor and Krivelj which are not operated, although they are said to show good values.

South Africa.—The report of the Cape Copper Company, Ltd., shows that

23,027 tons of ore were treated at Ookiep and Nababeep during the year ending April 30, 1903. No new developments have taken place with regard to the copper deposits in northern Rhodesia, which are said to be rich and of great extent. The district lies several hundred miles from a railway, and the difficulties of transport must be overcome before mining can be undertaken on a large scale.

Spain.—The Rio Tinto Company, Ltd., during 1903, produced 1,918,538 tons of ore averaging 2.39 per cent in copper. The shipments of pyrite ore to England, Germany and the United States by the company amounted to 667,748 tons, while the exports of sulphur ore were 118,171 tons. The pyrite shipped contained 14,245 tons of copper, which with the output of 21,565 tons at the mines gave a total production for the year of 35,810 long tons fine copper. The copper contents of the reserve heaps at the close of the year were estimated at 147,685 tons. The new smelting and bessemerizing plant was in full operation throughout the year, and has resulted in a considerable saving in the cost of producing copper. From the sales of ore and metal the company realized £1,648,110, to which is to be added the sum of £67,160 for other receipts, including the balance brought forward from 1901, making a total income of £1,715,270. From this sum the following amounts were set aside: £49,952 for depreciation account; £71,220 for redemption of bonds; £50,000 for reserve fund; and £2,500 for provident fund. There was also paid out for mining, smelting, and interest charges £306,721, leaving a net balance of £1,234,877, out of which were paid dividends of 5s. per share on the preferred stock, and 70s. per share on the common stock. The Tharsis Copper & Sulphur Company, Ltd., raised 348,413 tons of ore in 1903, producing 6,319 tons of refined copper. Nearly all of the ore was taken from the Catañas mine, as the Sagunazo deposit has been practically exhausted. The development work at the former mine has shown satisfactory results, large quantities of ore being opened, which run low in copper but high in sulphur. The net profits from the year's operations, after writing off £26,000 for depreciation, were £218,960, which, with the amount carried forward from 1902, gave a balance of £244,749. From this sum dividends amounting to £218,750 (or 7s. per share) were paid, leaving a surplus of £25,999.

The Copper Markets in 1903.

New York.—The past year was a fairly prosperous one for the copper industry of the United States. At no time did values go below the average price of the preceding year. On the other hand, there were at times sudden and wide fluctuations, mostly caused by the erratic policy pursued by leading producers. In how far the interests of the trade have been subordinated and sacrificed to operations in share speculations is a question often asked but difficult to answer.

Production during the year under review showed an increase over 1902, mostly as the result of a larger output at the Lakes and in Arizona, although the latter suffered somewhat from labor troubles, insufficient water supply and a lack of fuel during the Colorado coal strike. In Montana, continued litigation between the Amalgamated Copper Company and the United Copper Company acts as a check to a further development of the industry in that State.

As to consumption, the closing months of 1902 found many works in Europe shut down or running on half-time, leaving a growing army of unemployed workmen. In contrast, the volume of business in the United States surpassed all precedents.

At the end of the year there was an unusual demand from Europe, while here consumption showed a falling off during the last few months, in sympathy with the depression in the iron and steel trade. Generally speaking, however, as far as the first seven or eight months of the year are concerned, business in all lines was very good. There would, no doubt, have been an actual scarcity of the red metal if the disturbance in the financial markets had not caused a general curtailment of purchases and a putting off of new enterprises. As it is, the use of copper for traction purposes is increasing all the time, and the trials in utilizing electrical power for long distance travel continue to give very encouraging results. The production of sulphate of copper again absorbed fair quantities of the raw material.

The market in January opened rather active, with lake quoted at 12c., electrolytic at 11¾, casting copper at 11½c. Circulars and statistics, widely distributed on both sides of the Atlantic, announcing that enormous stocks had accumulated in the United States, were generally discredited. On the contrary, the trade began to recognize the stronger position of the metal, and consumers as well as speculators bought freely. Toward the end of January 12½ was paid for lake and 12⅜ for electrolytic copper.

During February the improvement made further progress, manufacturers both here and abroad being exceedingly busy. Very soon 13c. was reached, while at the beginning of March prices had advanced to 13½. The strong consumptive demand continued unabated throughout the greater part of April, carrying prices to 15c. for lake and 14¾c. for electrolytic copper.

During all this time, early deliveries were difficult to obtain, producers being well sold ahead, and it was not until the latter part of April that a reaction set in. Influenced by a pronounced weakness in the London speculative market, consumers began to curtail purchases and business became more or less restricted. Prices gave way slowly, lake being obtainable at 14¾ and electrolytic at 14½ cents.

Throughout May, both consumers and producers continued a waiting attitude, but at the beginning of June the market became rather flat, caused by the weak tendency of the stock exchange, as well as rumors of impending labor troubles. By the end of the month lake had declined to 14¼ and electrolytic to 14c. per pound. Renewed liquidation on the stock exchanges, which undermined confidence to a large degree, was the main cause of a further drop of 1c. per lb. during July. Even the settlement of the various building strikes had no effect whatsoever, consumers proceeding very cautiously and covering only their immediate requirements.

The month of August opened with lake selling at 13c. and electrolytic at 12¾, at which figures a fair volume of business was transacted. Stimulated by a decided improvement in the financial markets, consumers toward the end of the month again bought freely, values advancing slowly from week to week until 13½ for lake and 13¼ for electrolytic was reached by the middle of September.

Dulness reigned supreme during the greater part of October, quotations declining to 12¾ for lake and 12½ for electrolytic, until at the end of the month it was found that all mines and smelting works of the Amalgamated Copper Company in Montana had been shut down in order to bring about new legislation in that State. Naturally, this action caused a sensation. Consumers, being covered only for their immediate requirements, rushed in to buy, and values advanced by leaps and bounds, up to 13¾ being paid for lake and 13½ for electrolytic.

On November 11 operations were all at once resumed, and prices immediately started to go down, the month closing dull, with lake selling at 12½c. and electrolytic at 12⅜c. Under heavy selling pressure by leading producers there was a further decline at the beginning of December to 11¾ to 12 for lake and 11½ to 11¾ for electrolytic copper, which greatly puzzled the trade on this side. It seems, however, that manufacturers in Europe who were practically bare of supplies, and where business shows a considerable improvement, took advantage of the opportunity to a large extent, and bought heavily for early, as well as future, delivery. Thus it came about that when the home consumers finally entered the market they had to pay higher prices.

The year closed with lake quoted at 12⅛ to 12¼; electrolytic, 12 to 12⅛; casting copper, 11⅝ to 11¾c. per pound. Owing to the withdrawal of the largest factor from the Producers' Association, it was rather difficult to gather reliable statistics. In well-informed quarters, however, it is not believed that more than normal stocks of refined copper exist in this country.

The average price of electrolytic was higher by 1.609c. in 1903 than in 1902; while the lake average showed an increase of 1.630c. last year. The price of electrolytic approached that of lake very nearly, the difference in the yearly average being only 0.182c. per pound.

The average monthly prices of copper in New York for the last five years have been as follows, the figures being in cents per pound:

AVERAGE MONTHLY PRICES OF LAKE COPPER PER POUND IN NEW YORK.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
1899...	14.75	18.00	17.54	18.43	18.25	17.93	18.33	18.50	18.46	17.76	16.93	16.40	17.61
1900...	16.33	16.08	16.55	16.94	16.55	16.00	16.16	16.58	16.69	16.64	16.80	16.88	16.52
1901...	16.77	16.90	16.94	16.94	16.94	16.90	16.51	16.50	16.52	16.60	16.60	14.39	16.55
1902...	11.322	12.378	12.188	11.986	12.226	12.360	11.923	11.649	11.760	11.722	11.533	11.599	11.887
1903...	12.361	12.901	14.572	14.642	14.618	14.212	13.341	13.159	13.345	12.954	12.813	12.084	13.417

AVERAGE MONTHLY PRICES OF ELECTROLYTIC COPPER PER POUND IN NEW YORK.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
1899...	14.26	17.02	16.35	17.13	17.20	16.89	17.10	17.42	17.34	16.94	16.49	15.85	16.67
1900...	15.58	15.78	16.29	16.76	16.34	15.75	15.97	16.35	16.44	16.37	16.40	16.31	16.19
1901...	16.25	16.38	16.42	16.43	16.41	16.38	16.31	16.25	16.25	16.25	16.22	13.82	16.11
1902...	11.053	12.173	11.882	11.618	11.856	12.110	11.771	11.404	11.480	11.449	11.288	11.430	11.626
1903...	12.159	12.778	14.416	14.454	14.435	13.942	13.094	12.962	13.205	12.801	12.617	11.952	13.235

London.—January opened with a total visible supply in Europe, and afloat thereto, of 16,540 tons, while the actual stocks in England and France were only 11,215 tons, the price for standard copper being about £53 5s., cash, and £53 12s. 6d., three months. During the early part of January great activity was noticeable in England, Germany and the United States, manufacturers being full of work, and with every prospect of good trade. India was also buying manufactured copper with great freedom, and the year commenced with a very promising outlook, the price for standard copper improving to £54 5s., cash, £54 12s. 6d. three months; but when everything was at its most satisfactory level there was a communication, received by leading dealers and people interested in copper, from interested parties in America, stating that stocks on that side had accumulated to a very large extent, and predicting a speedy decline in values. This caused a certain amount of selling by bears, and unsettled trade with consumers, so that before the middle of the month prices had been forced down to £52 15s., cash, and £53, three months. Refined copper was scarce, and most of the European producers were holding for high prices. Towards the end of the month further gloomy reports were cabled from America, and this had a temporary effect of stopping buying, but the large demand for sulphate and manufactured copper had to be met, so that values rose again to £55 for cash and forward metal.

February saw a reduction in the total visible supply of 15,131 tons, while the amount of spot copper in Europe was only 9,356 tons. Prices during this month steadily advanced, owing to the very large trade that was forthcoming from all parts of the world. The Americans had to raise their prices, and even as they advanced them orders continued to roll in. When, however, the price of standard had risen to £58 5s. for cash and near dates, the market was again treated to further pessimistic predictions, which for the time being again checked the upward movement, and brought about a fall in the price of copper shares, which in turn reacted upon the copper market. But the enormous business that was doing again asserted itself, and prices once more took a jump, so that by the end of the month we had reached £59 7s. 6d., cash, and £59 10s., three months. The consumption in America was on an exceedingly large scale, and most of the producers were practically sold out for some time.

March commenced with a further shrinkage in stocks, which were 7,922 tons, the visible supply standing at 13,472 tons. With a few fluctuations the market quickly advanced to £67 5s. for April and May dates, this being caused by heavy bear covering which was induced by the continued large consumers' demand for copper in America. When the bears' most urgent needs had been covered there was a natural reaction, and prices dropped away, until just before the end of the month they had fallen to £63. At this point there was a fresh start, and the month closed with £65 as the nearest figure for both positions. Consumers continued to buy on a very large scale until prices of Standard commenced to decline, and then, as usual, took fright, and refrained from buying further. There being very little copper available for shipment from America enabled European producers to sell their productions at very full prices, compared with standard values.

April opened with a slight increase in stocks, which amounted to 8,059 tons, the visible supply being estimated at 14,384 tons. Copper shares were greatly affected in London, owing to the heavy fall in the price of consols and other high-class securities, and the American share market also becoming somewhat demoralized, helped to depress the price of copper. But the fall was principally confined to standard brands, and not to the copper required by consumers, and it was possible for Chile bars to be shipped from warehouse on this side to the United States for conversion into electrolytic. The price for standard, however, dropping to about £60 10s. for cash, encouraged a good amount of speculative buying, which caused a quick improvement again to £63 5s., but realizations quickly followed, and once more caused a speedy decline in prices, so that by the end of the month £59 2s. 6d. had been accepted for cash and three months.

In May, notwithstanding the large demand, stocks again increased to 9,023 tons, the visible supply being 15,998 tons. Further bear raids were indulged in, and, owing to the apathy on the part of buyers, prices were driven down. The lower level, however, brought in some speculative demand, and under this and bear covering there was a rally to £61 2s. 6d. The chief European producers were again able to market their output at a high level, owing to the full prices asked in America. India came in and bought fairly, but reports from America were not quite so satisfactory, and business showed some signs of getting quieter in that direction.

The total stocks in Europe at the beginning of June were 8,589 tons, the visible supply being 15,764 tons. The month opened with all the markets in America, both Stock Exchange and trade, in a very disorganized state; violent falls occurred in the chief copper shares, and large lines were thrown on the market to provide cover against other speculative commitments. This caused a rapid fall in the price of standard, which dropped to £55 12s. 6d., cash, and £54 17s. 6d., three months, but owing to the bear account again being somewhat large, and the available stock being well held, prices recovered again before the end of the month to £58 5s., cash, and £58, three months. During this month the United Metal Selling Company made the long-expected cut in prices, but although it was able to sell good quantities in its own country the consumptive demand here was only on a small scale.

July commenced with a slight increase in stocks, but a decrease in visible supply, which on July 1 stood at 8,903 and 15,303 tons respectively. The lower prices ruling stimulated trade with consumers in America, the United Metal Selling Company, the Calumet & Hecla and other producers meeting the demand at from 14 to 13.25c. Trade on this side remained very quiet until towards the end of the month, when good purchases were made by India and by sulphate makers. The speculative market opened at £58 5s., cash, and £58, three months, but, owing to the collapse of the American stock markets, values declined to £56 5s., cash. When it was found that warrants were going into one channel, and were scarce for early delivery, there was a bear flurry, which prevented the market from going to pieces altogether, and although forward prompts fell to £54 15s., cash, and near dates remained practically unaffected, a backwardation of nearly £2 for three months was established.

At the beginning of August the statistics were more favorable, stocks having decreased to 8,749 tons, and the visible supply to 14,949 tons. This fact, together with better reports from America, caused a renewed consumptive demand and considerable bear covering. The standard market, amidst great excitement, saw a fresh advance, spot at one time rising to £60 15s., with three months selling at £59 7s. 6d. Later on inactivity became the order of the day, and prices dropped to £58 and £57 10s. respectively. Very large sales were made in America and Europe of all classes of consumers' copper, and most of the principal producers were able to sell their make for this and the following month.

September saw stocks higher, at 9,412 tons, the visible supply being given as 15,712 tons. The standard market was adversely affected by the advance in the Bank of England rate of interest and renewed unsatisfactory American news, so that standard values declined to £55 all positions. The market for consumers' copper improved somewhat at the lower level, America buying Chile bars for shipment to the United States and sulphate makers paying high premiums for all suitable material.

October saw a decrease again in stocks, which stood at 6,041 tons, and the visible supply at 15,241. The very unsettled commercial and financial outlook in America had the effect of causing consumers in the States to abstain from buying, and, although the United Metals Selling Company reduced prices, very little trade was possible on this side, where manufacturers and speculators alike were frightened at the warlike news received from the East, where it looked as if trouble was brewing between Japan and Russia. When values of standard had been forced down to £53 12s. 6d., there was a quick recovery on the announcement that all the Amalgamated mines had been closed down. Some large speculative buying followed on the strength of this news, and standard rose to £60 15s., sulphate of copper makers also taking large lines of suitable stuff. Chile at this time took advantage of the improved state of affairs to market a good quantity of metal.

November opened with an absolutely idle market, consumers having bought largely, and speculators looking on. But suddenly the market received a shock by the receipt of news from America that all the Montana properties had recommenced working, and this forced a decline to £55 10s. for standard. A day or so after this news, the Rio Tinto strike collapsed, and the market quickly gave way under bear selling and realizations until £53 12s. 6d. was accepted. These violent movements naturally choked off consumers, and it was only owing to the scarcity of cash warrants, and all available near delivery material, that prices did not suffer to a greater extent. India commenced to buy at the lower range, and took fair lines of manufactured copper.

December opened at £54 15s., cash, and £54, three months, and remained a fair market notwithstanding the pressing offers of all kinds of refined American brands that were being sold in large quantities in Europe and this country by the United Metals Selling Company, and also by large American producers. This large selling was caused by the continued apathy on the part of the American consumers, so that producers, who wished to make sales, had to dispose of their goods in the European market, where buyers were tempted by the continuous decline in price. When the lowest level had been established, there was a quick movement in the upward direction, and it was found that American buyers were willing to enter the market. At one time the margin between standard and refined got exceedingly narrow, and electrolytic could have been bought at almost the net standard price. The closing quotations of the year were £57 for spot standard, and £56 12s. 6d. for three months.

The average monthly prices of standard copper—equivalent to the former G. M. B.'s—in London were as follows, in pounds sterling per long ton of 2,240 pounds:

AVERAGE MONTHLY PRICES OF STANDARD COPPER (G. M. B.'s) IN LONDON.
(In pounds sterling per long ton of 2,240 lb.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1901 ...	71.78	71.17	69.54	69.61	69.60	68.83	67.60	66.34	65.97	64.11	64.51	52.34	66.79
1902 ...	48.43	55.16	53.39	52.79	54.03	53.93	52.89	51.96	52.68	52.18	51.03	50.95	52.46
1903 ...	53.52	57.34	63.85	61.72	61.73	57.30	56.64	58.44	56.82	55.60	56.30	56.36	57.97

The minimum price was in January and the highest point of the year was reached in March.

Progress in the Metallurgy of Copper in 1903.

BY L. S. AUSTIN.

The Arizona Copper Company, Clifton, Arizona.—These works[1] smelt a mixture of sulphide concentrates carrying 20 per cent copper, with an equal amount of carbonate ore, together with precipitates from a leaching plant working on oxidized tailings. The five blast furnaces are each 39 in. by 240 in. There are five 7-ton converter-stands, but two only are in continuous operation. The flue-dust from the furnaces, going 8 per cent in copper, is bricked with the addition of clay and again fed to the blast furnaces. The flue-dust is collected in a flue 800 feet long, which runs up the mountain side, and is terminated by a stack 50 feet high. The compressors for the converters are operated, the one by a steam-engine, the other by a gas-engine. The blast furnaces produce a 55 per cent matte, which is stored in a reverberatory to be drawn from according to the needs of the converters. Thus any waiting, either of blast furnace, or of converter, is prevented, and the converters may be driven to their full capacity. The capacity of the plant is 15,000 tons of blister copper of 99.5 per cent annually. The copper carries practically no gold or silver.

Cost of Smelting at Butte, Montana.—As given by the superintendents of various works[2] for the latter half of 1901 and the first four months of 1902, the cost of smelting at Butte per ton of mine ore is detailed below:

	Montana Ore Purchasing Company.	Butte & Boston Con. Mg. Comp'y.	Colorado Smelting & Mining Co.	Boston & Montana C.C. & S. M. Co.
Transportation	$0.18	$0.15	$0.20	$0.15
Crushing and sampling	0.50	0.53	0.36	0.20
Concentration	0.70	0.70	0.70	0.75
Calcining ½ ton	0.22	0.26	0.33	0.42
Smelting ½ ton	1.53	1.21	1.18	1.59
Total	3.13	2.85	2.77	3.11

The average total cost of blast-furnace smelting at these plants is $5.20 per ton of calcines treated; the average total cost of reverberatory smelting was $3.92. To offset this, however, the blast-furnace slag contains 0.2 per cent copper only, while the reverberatory slag retains 0.6 per cent copper. The first-class ores averaged 15 per cent Cu, 50 per cent SiO_2 and 16 per cent Fe, at the Montana Ore Purchasing works, but at most of the works such ores would not exceed 12 per cent Cu.

Referring to the table above the following points are brought out: Transportation is given at about the same figures for the different companies, not-

1 *Mining Reporter*, February 26, 1903.
2 The Engineering and Mining Journal, May 9, 1903.

withstanding some of them are close to the mine and one at Great Falls, 150 miles away. Crushing and sampling vary from 20e. to 53c., being least at the largest plant. The power figure seems reasonable for a considerable tonnage. Concentration is about the same at the various plants. The ores averaged 3.2 per cent in eopper, and are eoneentrated three into one, but, as there is a loss of 30 per cent in eoneentration, this would mean an actual reduction of 3.65 into one. In recent praetice jigs are more used, so that a larger proportion of eoarser grains goes to the blast furnace, while the slimes are either mixed with quartz, for converter lining, or are briquetted and sent to the blast furnaee. The cost of calcining per ton of coneentrates varies at the different plants as follows: Montana Ore Purchasing Company, using the Herreshoff multiple hearth roasting furnaee, 47c. to 66e.; Butte & Boston Company, using the O'Hara furnaee, 78e.; Colorado Smelting Company, using the Pearee turret furnace, 98e.; Boston & Montana Company, $1.25.

Smelting costs show eonsiderable and unusual variation. Thus the total cost of smelting a ton of eoneentrates is:

Plant.	Blast Furnace.	Reverberatory.
Montana Ore Purchasing Company..	$5.96	$4.95
Butte & Boston Company..........	4.84	3.63
Colorado Smelting Company.......	....	3.55
Boston & Montana Company.......	4.78	....

The limestone used in smelting eost $1.25 to $1.40 per ton. For the first four months of the year 1902 the average cost of reduetion per ton of mine ore was $2.47—less than the figures of the table already given.

Notes on the Metallurgy of Copper in Montana.—With regard to metallurgical treatment the ores are eopper-silver, divided into first and seeond-elass.[3]

ANALYSES OF MONTANA ORES, MINED IN 1902.

	Plant A.				Plant B.	Plant C.			Plant D.		Plant E.		
	First-Class Ores. (av.)	Coarse Concentrates. (av.)	Fine Concentrates. (av.)	Slimes. (av.)	Average.	First-Class Ores.	Second-Class Ores.	Concentrates.	First-Class Ores. (av.)	Concentrates.	First-Class Ores.	Coarse Concentrates.	Fine Concentrates.
Cu........	11.4	15.7	11.2	6.0	7.0	12.7	5.2	8.7	9.5	10.0	8.0	6.0	9.0
Fe........	16.6	22.0	23.5	6.7	24.0	18.4	16.0	27.0	18.0	30.0	13.2	18.6	1.4
Zn........	0.3	0.5	tr.	tr.	12.0	....	....	....	....	....	....	....	....
S..........	22.6	29.4	30.9	9.5	32.0	24.8	19.8	34.7	22.5	36.5	18.0	23.0	34.0
As and Sb .	1.4	0.9	0.6	0.1	....	....	....	....	....	....	....	....	....
Al_2O_3.....	7.9	3.0	6.6	20.7	....	4.+	....	....	....	....	....	....	....
Insol......	44.7	30.3	27.3	71.5	23.0	40.0	56.0	25.4	47.5	23.0	54.0	45.0	28.0
$Si O_2$......	38.2	26.5	23.8	53.4	....	....	....	....	....	....	....	....	....
Ag oz	5.2	5.5	4.4	3.1	14.0	7.6	3.0	5.6	....	....	6.5	....	....
Au oz	0.014	0.02	....	....	....	....	....	....	....	....	....	....	....

3 Prof, H. O. Hofman, *Transactions* American Institute of Mining Engineers, February, 1903,

In general the first-class ore contains 10 to 15 per cent copper and is smelted direct, usually in blast furnaces, without having been roasted. The first-class ore constitutes about 10 per cent of the total product. The second-class ore, which constitutes 90 per cent of the ore mined, contains 3 to 6 per cent copper, and is concentrated. Fine concentrates are always roasted and, as a rule, smelted in reverberatory furnaces, thus avoiding much flue-dust loss, such as would occur in a blast furnace. Coarse concentrates above 5 mm. in size are often added to the blast furnace charges without having first been roasted, the quantity so added reaching 30 to 35 per cent of the ore.

Following are some of the leading facts regarding the Montana roasting furnaces:

DETAILS OF MONTANA ROASTING FURNACES.

	Tons Roasted 24 hrs.	Horse-power Required.	Sulphur in Concentrates.	Sulphur in Calcines.	Area of Hearths.	Concentrates per Sq. Ft. Hearth.	Coal per Ton Concentrates.		Cost per Ton.	Flue-Dust Made.
			Per Cent.	Per Cent.	Sq. Ft	Lb.	Lb.	Per Cent.		Per Cent.
(1) Hand-reverberatory furnace, 69½ ft.x16 ft. hearth	13	..	35	7–8	1112	12	307	15.3	$2.00	....
(2) Allen-O'Hara furnace, two hearths, 94 ft.x9 ft..........	51	3.64	35	8	1692	77	145	7.2	0.78	....
(3) Brückner cylinder, 8 ft.x16 ft. (8½ revs. per hr)..........	18–20	1½	37	9.5	....	....	540*	27.0	1.25	13.5 (?)
(4) Pearce single-deck furnace..	14‡	1½	32	7–8	505	55	400	20.0	0.98†	Very low
(5) Pearce double-deck furnace, 6-ft. hearths, 36 ft. dia	30‡	3	35	6–7	1010	59	400	20.0	0.98†	....
(6) Pearce double-deck furnace, 7-ft. hearths..............	42‡	3	35	6–7	1218	69	182	9.1	0.98†	....
(7) Keller-Gaylord-Cole furnace, two sets of six hearths.......	50	1¾	38	7–10	2592	38	67	3.3	....	....
(8) Wethey furnace, two sets of four hearths, 50 ft.x5 ft. In 1894.....................	60	4	40	8	2000	60	110	5.5	....	....
(9) Wethey furnace, two sets of four hearths, 65 ft.x10 ft. Since 1894................	90	4	35	5–6	2600	70	80	4.0	....	....
(10) Herreshoff furnace, five hearths, 10 ft. 10 in. diam....	5–6	....	35	6	135	80	....	....	0.50	6.4
(11) MacDougall-Evans-Klepetko furnace, six hearths, 15 ft. 10 in. diam...............	40	1⅔	35	7	952	84	....	....	.35	4.5
(12) Pearce multiple hearth furnace, six hearths	56‡	12	35	6–7	2947	38	28.5	1.4	0.98†	4.0

* Data obtained from operations of six months at Great Falls. † Average. ‡ These low figures are due to the character of the ore (Gagnon mine), which carries 8-12 per cent zinc.

For the blast furnace the charge consists of first-class ore in lump form, concentrates, limestone and converter slag. It will be noticed that where there are fines in the first-class ore, these are separated by screening and go to the roasting furnace. The first-class lump ore is occasionally roasted in open stalls such as have been described by Peters.[4] The operation of the stall, however, differs from that described by him. This consists in closing the front of the stall by an iron plate that comes down within two feet of the bot-

4 'Modern Copper Smelting,' 1895, p. 148.

tom. This plate is supported by wooden blocks, and the space between the blocks is filled with kindling wood. The plate is braced against outward thrust by iron cross-bars. During the roast the contents of the stall swell to their highest point and then begin to shrink, owing to a slight clinkering which always takes place, and the front plate gradually works down to the floor. A stall holding 30 tons of first-class ore with 10 per cent Cu and 30 per cent to 35 per cent S, burns thirty days, the sulphur being reduced to 3.5 to 4 per cent. Crushing and sampling the ore, running it to the stalls, filling and emptying the stalls, is done by contract.

The Allen-O'Hara Furnace (2).—This is one of the most advanced improvement on the original O'Hara furnace. The six carriages with their plows make a circuit in 3.75 minutes.[5] The ore bed is 3 in. thick and is therefore stirred once in 37 seconds. The ore is six hours in passing through the furnace and the ore charge usually contains 18 per cent of first-class ore fines. The labor involved is 4 hours for the car-man (who brings the ore); 4 hours for the fireman, 8 hours for the wheeler (who removes the calcines to the smelting department), and an hour for the repairer, during the day shift only. An average sample of the calcines gave Cu, 10.8 per cent; SiO_2, 31.6 per cent; Fe, 38.0 per cent; S, 7.6 per cent; Ag, 7.03 oz. per ton. An average analysis of flue-dust was Cu, 10.8 per cent; SiO_2, 34.4 per cent; Fe, 36.5 per cent; S, 8.2 per cent; Ag, 7.2 oz. per ton.

The Wethey Furnace (8, 9).—The rabble arms protrude and are carried by carriages running outside the furnace-hearths[6]. The tripping doors which close the continuous hearth-slot are, however, not used, the furnaces seeming to do well without them. The fire box has been changed so that the flame may enter the top hearth to dry and kindle the moist concentrates as they enter the furnace.

The Pearce Turret Furnace (5, 6, 12).—Three kinds of turret furnaces are used, the single-deck and the double-deck furnaces of Richard Pearce, and the six-deck or multiple-hearth furnace of R. F. Pearce.[7] The single-deck furnace (4) carries two stirrer arms, and roasts concentrates containing Cu, 7 per cent; Fe, 24 per cent; Zn, 12 per cent; S, 32 per cent; SiO_2, 23 per cent; Ag, 14 oz. per ton. The percentage of flue-dust is very low. The high percentage of sulphur remaining in the roasted ore is no doubt due to the high percentage of contained zinc. In the double-deck furnace, the partly roasted ore from the upper hearth drops through a slot upon the lower hearth, thus making more flue-dust than in the single-deck furnace. Comparing the pounds of ore roasted per square foot of hearth area in the single and in the double-deck turret furnaces (59 and 69 lb.), an improvement of 15 per cent in favor of the 7-ft. hearth is seen. The degree of desulphurization is about the same in the two furnaces; the consumption of fuel, however, has been reduced from 400 to 182 lb., or 55 per cent.

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5 Hofman, 'Metallurgy of Lead,' 1899, pp. 186–190. 6 *Idem*, pp. 196–198. 7 *Idem*, pp. 175–182.

The six-deck furnace resembles the double-deck in the stirring mechanism and in the movement of the gases. It has one fire-box (3 ft. by 3 ft. 2 in. grate area) on the hearth, and one (4 ft. 3 in. by 3 ft. 2 in. grate area) on the bottom hearth. There are no air spaces between the superimposed hearths, the roof of one forming the floor of the one above. The portions of the inner wall above the lower hearth are supported by cantilevers with trussed chords, sustained by the center column. This makes a complicated structure, requiring many parts of various sizes, some quite heavy. The iron parts of a furnace aggregate 125 tons. Each hearth has four stirring arms, making a revolution in 65 seconds. Around the furnace are platforms to give access to the various hearths. The ore is fed by a corrugated roller feed through a slot (8 in. wide by 7 ft. long) in the roof of the top hearth. As compared with the two-deck furnace the ore roasted per square foot of hearth area is less, but, on the other hand, the saving of fuel is very large.

The McDougall Furnace (11).—Three kinds or varieties of this furnace are mentioned here, the original McDougall, the Herreshoff and the Evans-Klepetko. The original McDougall furnace had to be abandoned because of the large amount of fuel-dust formed and the many mechanical difficulties encountered.

The Herreshoff Furnace (10).—These furnaces have a quarter-inch steel casing. They are 10 ft. 10 in. in diameter, 11 ft. 6 in. high, and are lined with a full course (8 in.) of brick. A few furnaces built with two full courses of brick, and hooped with iron bands, keep hotter and give better performance, especially on ores running low in sulphur. In operation the top hearth acts as a dryer; the second starts the roasting; on the third the ore roasts freely, giving out innumerable sparks; on the fourth there are no sparks, but the ore is quite red; on the fifth floor the ore looks dark and is cooling. Firing with fuel is performed much on the plan pursued for the Evans-Klepetko furnace, a description of which follows:

The Evans-Klepetko Furnace.—The leading differences between the Herreshoff and the Evans-Klepetko furnaces are the size, the water-cooling of the central shaft, and the stirring. The latter furnace is 18 ft. 3.5 in. high, and 15 ft. 10 in. in diameter. The shell is 3/8 in. thick and is lined with a full course of red brick. It has 6 arched hearths (Fig. 2) with a 9 in. spring and 3 ft. apart. Each hearth has two water-cooled rabble arms (Fig. 6), upon which the rabbles, also shown, can be slipped or removed as desired. The furnace stands on columns 12 ft. high (Fig. 1) to allow the roasted ore to be collected in hoppers and drawn into cars. Each furnace has two outlet flues to the 6 ft. main, on which there are bottom openings connecting by vertical pipes to the hoppers. The furnace is driven from a main shaft, through friction clutch and bevel gears, as shown. The cooling water is forced down a 3-in. pipe, and into each arm through a 1-in. pipe, thence back through the rabble-arm to the central shaft, and finally discharges at the top through spouts to a stationary launder. Shafts and arms are made up in sections for easy repair and replacement. In operation they make one revolution per minute. With the temperature of the discharged water at 80° C., 20 gallons per minute are needed per furnace. When ores too low in sulphur to be self-burning (less than 28 per cent S) are to be roasted, one auxiliary fire-box furnishes sufficient heat for two furnaces. These fire-boxes placed at the level of the lower hearth deliver the flame at the fourth hearth. The moist concentrates from the ore-dressing plant are dumped into ore-hoppers above the furnace. The tops of the hoppers have gratings to keep out large lumps that may have

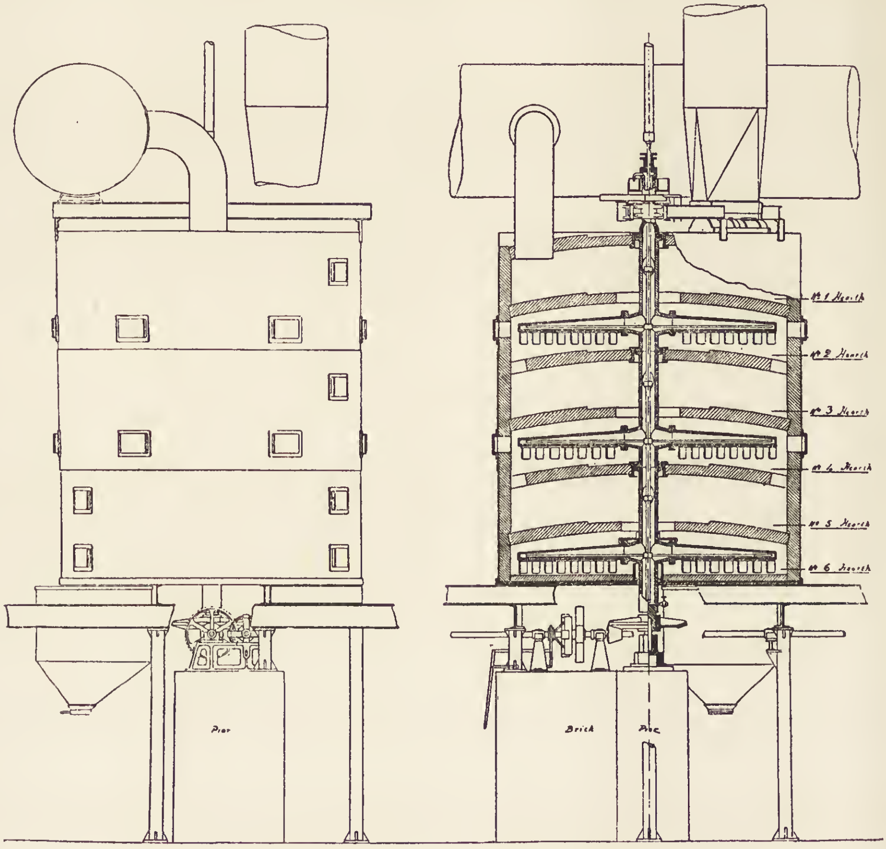

FIG. 1. ELEVATION. FIG. 2. SECTIONAL ELEVATION.
THE EVANS-KLEPETKO FURNACE.

gotten accidentally into the ore. The capacity of the hopper is 33 tons. The ore is fed to the furnaces by means of a feeding-scraper, that has a reciprocating motion by which the ore is pushed off a shelf placed below the hopper, as more particularly shown in Fig. 5. An adjusting nut permits the feed to be regulated so as to give about 3 in. in depth of ore on the upper hearth. The outer half of the hearth is 9 in. thick, the inner 6 in., thus saving in brick and in weight. A loose-working bottom made of crushed limestone, sometimes flue-dust, or even of coke-dust, makes a suitable working floor. Of the two arms of each hearth one has seven and the other eight rabbles. The cast-iron rabbles (Fig. 6) are 8 in. long and 6 in. wide, and the blades ⅝ in. thick. The lower three inches of the blades, that come in contact with the ore, are chilled. As the blades are worn off the hearth builds up. When they are to

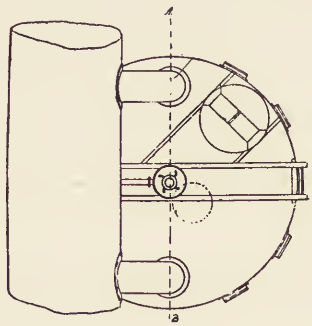

FIG. 3. PLAN.

FIG. 4. PLAN OF HEARTH.

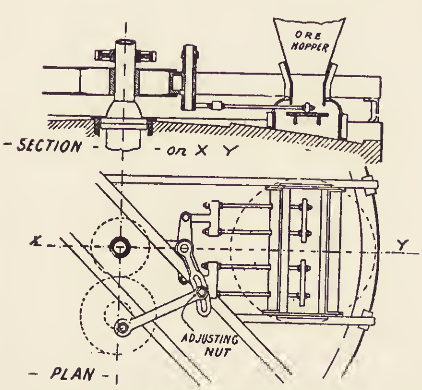

FIG. 5. DETAILS OF FEED GEAR.

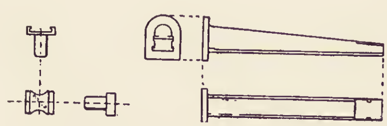

FIG. 6. DETAILS OF RABBLE AND DRUM.

THE EVANS-KLEPETKO FURNACE.

be renewed, they are removed and a plow is slipped on the arm and moved a little towards the center at each circuit of the arm, easily and surely breaking the old crust. The crusts on the second hearth are the hardest to break up. The blades on the top hearth last 25 to 34 days, those on the bottom hearth 6 to 8 months, the shorter life of the former being no doubt due to the decrepitation and action of the sulphur on the blades. The draft is equal to 0.3 in. of water. Roasting begins on the second or third hearth, varying with the strength of the draft and the revolutions of the arms. With a strong draft the heat creeps up; with one revolution in 55 seconds the roast begins on the second hearth, with one in 75 seconds on the third. As the ore passes from the first hearth through the annular opening (lined with a cast-iron ring) at the center of the roof, it strikes a distributor, which guides it under the nearest rabbles. During normal work three doors on the bottom hearth are left open for the admission of air. If the furnace becomes too hot the doors on the third floor are opened somewhat, and thus the draft is checked. While the ore drops from hearth to hearth the upward gas current carries the flue-dust against the roof, where it adheres in part and builds up. In order to guard the arms at these places they are protected by cast-iron caps (Fig. 6). When the dust has grown to a thickness of 4 in. it is removed with chisel-pointed bars. Experiments to protect the roof at weak spots have proved successful, as the accumulated dust is easily pried off. The chunks go to the blast furnaces as welcome lump ore. They carry only 6 per cent SiO_2, while the ore carries 30 per cent SiO_2. It indicates that the light particles of Fe_2O_3 are more adherent than the gangue. The flue-dust from the chambers is higher in sulphur than the calcines. In starting a furnace, crushed limestone is fed to form the working-bottom. A fire of dry, soft, long-flaming wood is started from the side doors of the third and fifth hearths. A new furnace is brought to a dark red in three or four days; an old furnace requires only two days. After feeding for five or six hours it sometimes happens that the furnace cools too much, and it becomes necessary to start new fires again for an hour and a half to two hours. Occasionally the feeding of the ore is stopped, and half a ton of coal is charged. When this has come to the third hearth, the machinery is stopped and the coal is allowed to burn out. The kindling of the coal may have to be assisted by placing dry wood on the hearth. Normally the furnace works best with 0.3 in. of draft; with less it gets cool. The regular charge works through the furnace in 90 minutes. If the furnace gets too hot, more slimes (comparatively lower in sulphur) are fed; if too cold coarse concentrates are charged and less ore fed. The temperature is further regulated by the admission of air; closing the bottom doors drives up the heat, opening them draws it down, while opening the upper doors checks the draft below them. The rate of feed and the revolutions per hour, when once settled, is usually not altered. The flue-dust is removed from the main flue daily, and the dust collecting in the branch or outlet flue is blown out into the main flue with a hose under 90 lb.

pressure. The output of the furnace varies with the revolutions; at 48 revolutions per hour the output is 30 tons; at 60 revolutions it is 40 tons, and at 70 revolutions the tonnage becomes 50 to 55 tons. For a section of 6 furnaces the labor per 8-hour shift is as follows: 1 furnaceman, 1 helper, 1 trimmer, and one-third time of foreman, one-sixth time of oiler, and one-ninth time of repair man. The average analysis of the ore during a 15-day trial is as follows: SiO_2, 26.9 per cent; Cu, 18.3 per cent, of which 9.9 per cent was present as CuO; Fe, 30 per cent, of which 17.9 per cent was present as FeO; S, 9.2 per cent, of which 0.81 per cent was present as SO_3. The matte formed in a crucible fusion of this product was 65 per cent. In comparing the product of the McDougall type furnace with that of the Bruckner furnace we find that the calcines of the former are reddish brown (containing more Fe_2O_3), as against dark brown in the latter. The Bruckner furnace product weighs 100 lb. to the cubic foot, as against 87 lb. of a more porous fine product in the McDougall.

Smelting Ores in the Blast Furnace.—The leading data of the blast furnace practice are given in the accompanying table. The furnaces are of the same general type. They are rectangular and water-jacketed, are run with open breast and with a continuous flow, through a water-jacketed spout to a large forehearth, where the separation of matte from slag is effected. The slag overflow from the forehearth is granulated in a stream of water, or is caught in the 5- or 6-ton pots of tilting slag cars, conveyed by electric motor to the dump, and poured.

The tendency has been to increase the size of the furnaces. With the fine ores of Butte the attempt to increase the width of the furnaces has been unsuccessful. A screen analysis from one principal mine is as follows: Over 2 in. in diameter, 13.3 per cent; between 2 in. and 1 in., 20.0 per cent; between 1 in. and 3/8 in., 22.2 per cent; under 3/8 in., 44.5 per cent.

In the higher furnaces, the top of the charge is carried some 4 ft. below the charging door so that the actual working height (smelting column) is only about 14 ft. All furnaces are run with a top more or less hot. Temperature measurements of the escaping gases show as high as 314° C., the draft measurement being 0.8 in water. The steel water-jackets are two-high, the space between them and the feed-door being filled in with brick. There are usually two jackets at the side and one at each end. The bosh is made in the lower jackets only, the upper ones, as well as the end jackets, being vertical. The furnace gases are drawn off above the floor. One furnace is fitted with a Giroux blast-heater made by the Union Iron Works, San Francisco, that raises the temperature of the blast to 150° C. The charge is generally hand-fed, and at the sides of the furnace (sometimes at the ends), while in some instances with the large furnaces putting through upwards of 400 tons in 24 hours, automatic feeding has been introduced. In this system the charges are brought in tilting charging cars, electrically operated, to the furnaces, the doors are raised by compressed air and the charges slid in alternately at the

EXAMPLES OF MONTANA BLAST-FURNACE SMELTING.

Furnace.	A.	B.	C.	D.	E.	F.
Horizontal section at feed door	66 in. x 112 in.	54 in. x 96 in.	72 in. x 180 in.	53 in. x 160 in.	72 in. x 180 in.	72 in. x 180 in.
Horizontal section at tuyeres	42 in. x 112 in.	44 in. x 96 in.	56 in. x 180 in.	42 in. x 160 in.	56 in. x 180 in.	36 in. x 180 in.
Area at tuyeres	32.66 ft.	29.329 ft.	70.029 ft.	46.629 ft.	70.29 ft.	70.29 ft.
Height, tuyeres to feed door	7 ft. 3⅜ in.	9 ft.	18 ft.	10 ft. 6 in.	18 ft.	18 ft.
Height, top of crucible to tuyeres	16 in.	9 in.	11 in.	9 in.	11 in.	11 in.
Water-jackets, height	9 ft.	6 ft.	14 ft. 10 in.	10 ft. 6 in.	14 ft. 10 in.	14 ft. 10 in.
Bosh, inches in feet	12 in. in 6 ft. 4 in.	7 in. in 5 ft.	8 in. in 7 ft.	1 in. in 10 in.§	8 in. in 7 ft.	8 in. in 7 ft.
Crucible, depth	8 in.	16 in.	27 in.	9 to 14 in.	28 in.	28 in.
Forehearth, fixed or movable	Fixed.	Fixed.	Fixed.	Fixed.	Fixed.	Fixed.
Forehearth, shell dimensions	8 ft. x 5½ ft. x 3 ft.	12 ft. di. 52 in. deep	14 ft. di. 56 in. deep	7 ft. 3 in. x 10 ft. 6 in. x 4 ft.	14 ft. di. 56 in. deep.	14 ft. di. 56 in. deep.
Tuyeres, number	16	12	32	18	32	32
Tuyeres, diameter	3 and 3½ in.	2½ in.	3 in.	4 in.	3¼ in.	3¼ in.
Tuyere-ratio*	3.5	2.01	3.23	4.85	3.79	3.79
Blast, pressure, oz	16†	24	35	30 to 32	28	28
Blast, cu. ft. per ton of ore	57,000	68,574	65,000	......	......	60,176‖
Blast, temperature, degrees C.	150	15	15	15	15	15
Charge (ore + flux), weight, lbs.	3,300	2,400	2,150	4,000	8,700	10,000
Charge, tons in 24 hrs.	125	165	400	220	400	450
Charge, tons per sq. ft. hearth-area	3.82	5.56	5.71	4.71	5.71	6.43
Coke, per cent ash	20.0	21.3	9 to 15	20.0	8.0	8.0
Coke, per cent on charge	13	12.3	6.1	11.5	9.2	8.5
Men, number in 8-hr. shift‡	5+2	4+2	3 x 2 11/16	4¼+3¼	3+	4+
Matte, per cent on charge	......	5.1	......	......	......	5.5
Matte, Cu per cent	50	46	49	38	42	42.12
Zn per cent	......	......	1.0	......	......	......
Ag oz.	69	52	20	......	......	......
Au $	2	10	......	......	......	......
Sp. gr.	......	......	5.0 to 5.1	......	......	4.8
Slag SiO_2	47.7	44.3	40.7	48.0	40.0	42.6
Fe(Mn)O	18.5	27.0	26.2	17.0	23.0	30.7
Ca(Mg)O	28.2	23.0	19.4	20.0	22.6	19.5
Al_2O_3	......	9.0	9.6	6.0	9.8	......
Cu	0.35	0.32	0.25	0.30	0.30	0.25
Ag	0.43	0.30	......	......	0.20	......
Sp. gr.	......	......	3.0 to 3.55	......	......	3.3

* Sq. in. tuyere-area: 1 sq. ft. hearth-area. † Estimated at 50 per cent of the rated capacity of the blowers. ‡ First figure represents the regular crew, second figure auxiliary labor. § Lower jackets only. ‖ Ore-flux.

two sides. The system seems satisfactory, since having been worked out at one plant, it has been introduced at another. The hearth in some plants is supported on jack-screws; in other cases it is built up from the ground. The crucible is set so as to command the forehearth, which in turn must be set so as to permit the slag-car to run under the spout. The hearth is lined to the depth of 24 to 30 in. with fire-brick, sometimes with a mixture of quartz and clay overlaid with one or two courses of fire-brick on end. The crucibles are from 8 to 28 in. deep. Although the deep crucibles rarely last more than three months, while the shallow ones are more durable, yet the former are more common. It is claimed for the deep crucible that more charges can be put through when using it; moreover, with the deep crucible, the water-cooled jackets can be placed well above the molten bath. Lining deep crucibles with chrome brick has been tried with very encouraging results, and especially in preventing break-outs of matte. The slag-tap is generally at the middle of the side of the furnace, and is furnished with a tap-jacket of cast-iron, or preferably of copper, but not of bronze. The solid cast-iron spout with a water-cooled nose is quite common. Wrought-iron pipe surrounded by cast-iron has proved unsatisfactory. A water-cooled wrought-iron spout with a cast copper removable nose lasts about 120 days, and is preferred to cast-iron. The tuyere connection in common use consists of a cast-iron tuyere box bolted to the jacket and connected to the bustle-pipe by a sheet-iron pipe fitted with a cut-off valve.

The large-sized circular forehearth is a development of Montana practice, due to the necessity of storing considerable quantities of matte for the converters. The sides of these hearths are well away from the corrosive action of the hot matte, the matte is well settled and the heat is well retained in the large body of matte present. A circular forehearth 14 ft. in diameter and 56 in. high has a 9-in. brick lining and a 9-in. brasque backing. Sometimes the 9-in. brick lining has a 3-in. sand backing, which seems sufficient. The forehearth is sprayed on the outside when there is danger of its breaking out, by means of an encircling spray-pipe. Its capacity when new is 60 tons, but in the course of three months it has decreased in internal diameter owing to building up (accretions) and must be renewed. The tapping-slot for matte is closed in a few instances by means of a cast-iron plate, but more commonly by a solid copper plate. The matte is tapped into a ladle, which either conveys it direct to the converter or passes it into flat cast-iron moulds capable of holding 3,000 lb. The blast furnace forehearth is of great assistance in a plant operating also reverberatory furnaces, as it can act as a store place for matte from the reverberatory. It matters little whether the blast furnace forehearth, though always full, contains much or little matte. With the reverberatory this is not the case, since the level of the matte should vary as little as possible. This means that the tapping of matte shall be limited in quantity. If the converter calls for more matte than usual, and the reverberatory furnace cannot furnish a sufficient quantity, there is the forehearth that can supply the sudden demand without damage to its operation.

To obtain large tonnage it has been necessary to increase the size of the furnaces. In running them the aim has been to produce a 50 per cent matte and a slag sufficiently free from copper to be thrown away. Silicious limy slags are necessarily made, and, with an abundant air blast, as much as 70 per cent of the sulphur is burned off during the descent of the charge. But even with such a large elimination of sulphur it is often difficult to keep up the grade of the matte to the 50 per cent needed by the converter, and hence blast-furnace matte is sometimes tapped from the forehearth into a ladle and transferred to the reverberatory, where it becomes mixed with a higher grade matte.

The following shows the percentage composition of some blast furnace charges:

Plant.	First-class Ore.	Coarse Concentrates.	Matte.	Converter Slag.	Briquettes.	Limestone.	Coke.
A	22.4	20.5	4.0	17.8	4.0	22.8	8.5
B	52.5	....	2.3	8.9	....	25.6	10.7
C	15.5	25.0	22.5		0.2	27.6	9.2

When the converters are not ready it sometimes happens that matte has to be tapped from the reverberatories into moulds. It is this matte as well as purchased matte which constitutes part of the charges above given. The converter slag goes to the blast furnace, where it is a welcome addition to the charge. It can also be better cleaned from copper than if it went to the reverberatory furnace. The briquettes are a mixture of flue-dust, with 3 to 4% of slacked lime; sometimes slimes from the ore-dressing works are added. Following are analyses of flue-dust and briquettes:

Flue Dust from	Cu.			SiO_2.	Fe.	Al_2O_3.	CaO.	S.		As and Sb.	Ag. Oz. per ton.
	Total.	Soluble in H_2O.	Soluble in H_2SO_4.					Total.	Soluble in HCl.		
Flue near McDougall Fur.	13.3	....	....	47.9	11.9	....	....	12.0	....	....	4.2
" "	11.8	....	....	52.0	11.0	....	....	7.9	....	....	4.8
Blast Furnace	10.6	....	....	33.2	18.7	....	....	10.7	....	....	5.3
" "	10.4	4.2	5.7	26.5	13.9	37.7	4.2	7.3	5.3	1.6	....
" "	12.8	....	....	34.8	16.3	....	....	13.3	....	....	....
Dust chamber	13.3	1.6	5.4	31.7	8.3	15.8	0.5	7.6	....	....	....
" "	7.2	....	....	34.3	11.9	13.3	....	7.3	....	....	3.4
Stack	....	....	....	....	....	....	....	....	....	....	....
"	6.3	....	....	40.0	20.8	....	....	9.3	....	....	54.0
Briquettes (dust and slimes)	6.5	....	....	63.0	13.0	5.3	....	8.0	....	....	....
	....	MgO	H_2O	....	....	....	....	....	....	....	....
" (dust)	12.5	0.8	13.1	36.0	13.9	11.0	2.7	9.0	....	....	5.0

Smelting in the Reverberatory Matting Furnace.—The present practice at Butte consists in the use of a furnace with a hearth area of 880 ft., the hearth being 50 ft. long by 20 ft. wide.[8] (See Fig. 8.) Such a furnace treats 105 tons of charge in 24 hours, producing 50 per cent. matte, with concentration of 4 into one. These large furnaces have many advantages over smaller ones aside from greater capacity. The sides are less easily corroded by the slags (claying is done every 12 days as compared with every 3 days in the small furnace) since for a given amount of charge proportionately less surface is exposed to the slag. There is also less variation of temperature in this great reservoir of heat, and this also tends to lengthen the life of the brick; the slag layer is thinner, so that the charge is more quickly heated, and there is less foaming, as the charge is dropped from the hoppers, while the level of the matte remains more constant.

The fuel used is bituminous coal of various grades from Montana, Wyoming and Utah. Most furnaces are direct-fired. Some furnaces have natural draft; others have under-grate blast. In one instance the original fire-box

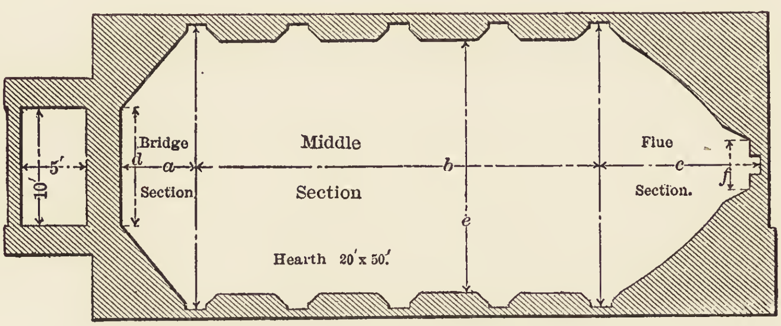

FIG. 7. HORIZONTAL SECTION OF MELTING FURNACE USED IN MONTANA AFTER 1891.

has been changed to receive a Duff (Pittsburg) gas producer, with most satisfactory results as regards the saving of fuel and speed of heating. The latter result is due to the fact that an ordinary grate has to be cleaned every four hours, while the grate of the Duff producer needs attention only once in 24 hours. On account of structural difficulties, however, the producer had to be given up. In order to utilize waste heat from the reverberatory, one Montana plant has attached a 300-h. p. Sterling boiler, Class A 2½, with 3,019 sq. ft. heating surface, to one of its 50 by 20-ft. furnaces. An attempt to use a boiler in this way at an eastern refinery proved a failure owing to its injuring the draft. Here, however, where the draft was strong and abundant, it has proved a great success. Indeed the working of the furnace was improved, since before putting in the boiler the flame was drawn even too rapidly through the furnace. By putting in dampers at the other furnaces to suitably check the draft, the other furnaces, which had no boilers, likewise improved in performance.

8. The Mineral Industry, 1902, p. 200.

One plant (E) only has reverberatory matting-furnaces with regeneration chambers. The gas producer used is the Evans-Klepetko, a modification of the well-known Taylor producer. It is 15 ft. high and 7 ft. diameter at the bosh. It gasifies 10 to 12.5 tons coal in 24 hours. The coal used is crushed to pass a 0.75-in. ring and passed over a 5-mm. screen. The oversize goes to the producers; the fines (30%) go to the boilers. Each reverberatory requires six of these producers; the flue from them has to be fired once in eight days to remove soot, tar, etc., and washed out once in six weeks to free from ashes. An average of the producer gases is CO_2, 9.4 per cent; CO, 16.8 per cent; CH_4, 2.9 per cent; H, 13.3 per cent; N. 57.6 per cent. The proportions of the reverberatory are given at E, in the table. The furnace is built in five sections to permit expansion, and since when heated up the crown of the arch rises as much as 9 in., the tie-rods are placed at least 12 in. above the roof, which is 9 to 12 in. thick. The lower tie-rods, which are carried 4 ft. below the brick hearth supporting the quartz bottom, were at first arranged to go through 4 in. wrought-iron pipes. When these burned out the new tie-rods were provided with a small central opening for water cooling. At present the rods are 1.5 in. diameter, and pass through a flue 2 ft. 6 in. by 3 ft. 8 in., which is ample for air cooling. The working or sand-bottom (called hearth in the table) ranges from 19 to 28 in. at the lowest point at the tap hole. Both single and double bottoms are found. The single bottom is more common in ore-smelting, as here the charge is lighter than that in the refining furnace, where the double bottom is used. The bottom sand is a sugar-like quartzite of 95 per cent SiO_2 and 5 per cent Fe and Al_2O_3. It is crushed to about No. 3 mesh, so that 80 per cent of it will pass a 5-mm. screen.

The following different ways of putting in a bottom indicate great differences in practice. A furnace 20 by 50 ft. will take in all 73 tons of crushed sandstone, and make a bottom of about 20 in. deep. Supposing the furnace to be dry and warm, 6 to 7 tons of the sand are charged and fired on for 6 hours, being rabbled at intervals. A like quantity of sand is then added, rabbled and fired on as before, and thus successively until about half the total sand has been added. The whole is now strongly fired on until the sand becomes fritted on its surface. The second half is then charged and worked in the same manner as the first half, and again brought to fritting. Converter slag is then poured in to cement the particles of sand more firmly together. From 3 to 4 charges of calcines are worked, and the furnace tapped dry after the last charge. The furnace is allowed to cool for 3 to 4 hours, and is then ready for regular work. The time needed for putting in such a bottom is 4 days. One installed in February, 1900, showed but little wear in June, 1902.

The other method of putting in a bottom is practiced in gas-fired furnaces having regenerative chambers. Let us suppose the furnace is new and needs drying out and warming up. A light wood fire is started on the hearth in

EXAMPLES OF MONTANA REVERBERATORY-FURNACE SMELTING.

	A.	B.	C.	D.	E.	F.
Length of hearth	50 ft.	50 ft.	49 ft. 6 in.	50 ft.	42 ft. 6 in.	37 ft.
Length, a, of bridge-section*	6 ft.	6 ft.	4 ft. 6 in.	6 ft.	42 ft. 6 in.†	....
Length, b, of middle-section*	28 ft.	32 ft.	32 ft.	32 ft.	42 ft. 6 in.†	16 ft.
Length, c, of flue-section*	16 ft.	12 ft.	13 ft. 0 in.	12 ft.	42 ft. 6 in.†	....
Width, d, of hearth at bridge*	10 ft.	10 ft.	10 ft. 9 in.	10 ft. 9 in.	15 ft. 9 in.	8 ft. 0 in.
Width, e, of hearth at middle*	20 ft.	20 ft.	20 ft. 2 in.	20 ft.	15 ft. 9 in.	14 ft. 6 in.
Width, f, of hearth at flue*	4 ft.	6 ft.	4 ft.	4 ft.	15 ft. 9 in.	5 ft. 0 in.
Hearth-area, sq. ft	842	886	878	878	688	....
Hearth, thickness	22 in.	24 in.	19 in.	20 in.	28 in.	22 in.
Length of grate	10 ft.	10 ft.	7 ft.	10 ft. 9 in.		8 ft.
Width of grate	5 ft. 5½ in.	5 ft. 4 in.	5 ft. 6 in.	5 ft.		6 ft.
Depth of grate below top of bridge at bridge	1 ft. 10 in.	2 ft. 9½ in.	2 ft. 4 in.	2 ft. 8 in.	Producer-Gas, Regenerative-Chambers.	3 ft. 0 in.
Depth of grate at opposite end	1 ft. 2 in.	2 ft. 6¼ in.	1 ft. 4 in.	2 ft. 2 in.		....
Grate-area, sq. ft	53.9	53.3	53.0	53.75		48.0
Ratio, hearth: grate-area	15.6	16.6	16.5	16.3		....
Height of roof above bridge	2 ft. 7 in.	2 ft. 6½ in.	2 ft. 10 in.	2 ft. 8¾ in.	24 in.	2 ft. 0 in.
Height of roof above hearth at bridge	4 ft. 8 in.	4 ft. 4 in	4 ft. 4 in.	4 ft. 8 in.	7 ft. 0 in.	4 ft. 10 in.
Height of roof above hearth at flue	2 ft. 1½ in.	2 ft. 10 in.	3 ft. 0 in.	2 ft. 2 in.	....	2 ft. 4 in. to 2 ft. 8 in.
Width of bridge	3 ft. 0 in.	3 ft. 5¼ in.	3 ft. 0 in.	3 ft. 0 in.	4 ft. 1½ in.	....
Size of flue at vulcatory	6 ft. x 30 in.	6 ft. x 30 in.	5 ft. x 30 in.	6 ft. x 30 in.	....	36 in. x 6 ft. 6 in. to 7 in.
Size of flue leading to chimney	30 in. x 48 in.	30 in. x 30 in.	28 in. x 30 in.	30 in. x 30 in.	42 in. diam. at ea. end	30 in. x 36 in.
Chimney, inside diameter	5 ft. 6 in.	6 ft. 3 in.	6 ft. 0 in.	6 ft. 1 in.	....	4 ft. 6 in. x 4 ft. 6 in.
Chimney, height	70 ft.	....	70 ft.	75 ft. 3½ in.	....	80 ft.
Charge, weight, tons	25	15	24	18	35	13
" time of melting, hours	5	3½	6½	4¾	6	5½
" tons in 24 hours	112.5	105	90	907	150	70
" tons per sq. ft. hearth in 24 hours	0.129	0.118	.102	0.102	0.218	....
Rate of concentration	5.7:1	4.7:1	7.56:1	5:1	3½:1	5:1
Fuel, bituminous coal, manner of firing	Direct.	Direct.	Direct.	Direct.	Prod. gas.	Direct.
Per cent ash	8.9	15.0	14.85	5.0	17.0–30.0	7–10
" " fixed carbon	51.9	44.5	44.5	55.0	45.0	50–52
Tons charge: 1 ton coal	3.05	3:1	4:1	2.81:1	2:1	2.5:1
Labor, in 8-hour shift	2+2	2+2	2+2⅓	2¾+1½§	§	2½+1⅓
Matte, Cu	53.8	48.3	50	50	50	55
Ag ozs. per ton	45	35	100	66	20	....
Au $ per ton	....	....	....	2(?)	....	....
Spec. gr.	....	4.8	....	....	4.77	....
Slag, SiO_2	36.8	42.8	34.5	38.6	41.9	49
Fe(Mn)O	51.9	47.31	43.0	51.4	42.7	32–36
Al_2O_3	8.4	7.5–8.0	8.5	1.5	10.9	....
ZnO	....	....	14.0	....	....	....
CaO	1.1	1.2	....	3.3	1.1	....
Cu	0.75	0.40	0.60	0.40	0.58	0.65
Ag	0.45	0.30	1.0	0.40	....	....
Spec. gr.	....	3.58	....	....	3.54	....

* See Fig. 3. †The hearth has the form of a rectangle. ‡ The first figure represents the regular crew, the second the auxiliary crew. § Not comparable in this manner on account of gas producers.

half a dozen places, and the valves are reversed every half hour. In 10 days the furnace will be at a dull red, and in 2 days more will be hot enough to ignite producer-gas. The gas is turned on in small amounts at first; after 3 days the wood ashes are taken out and a day or two later the furnace will be at a bright cherry-red. Five tons of sand are dropped from the hoppers and spread over the hearth to the depth of 2 in. The sand is rabbled and brought to the normal heat. Charging of similar portions of sand heated in the same way are made at 5- to 6-hour intervals until the whole 60 tons of sand has been introduced, making in all a bed 28 in. thick. The furnace is now brought in 36 to 48 hours to the highest possible heat, and the sand to a set of about 3 in. in thickness. This high heat is maintained for 16 hours more, and the furnace cooled in 8 hours to a dull cherry-red. About 7.5 tons of calcines, capable of producing a 45 per cent matte, and making a layer of 3 in. deep, are charged in. They are melted down and absorbed by the sand bottom. The furnace is cooled as before, and another charge of calcines given and smelted. Part of the charge will be taken up by the hearth; the rest is tapped out. The furnace is again cooled, 12 to 15 tons ore charge is given, melted down, the furnace tapped dry and cooled to a dark red, but more slowly than before. It is again fired up, worked under regular conditions for three days, tapped dry and allowed to cool to a cherry-red. It is now safe for any kind of work. The object of the repeated coolings of the bottom is to harden it. A bottom put in without such coolings is liable to be mushy when hot, even though hard when relatively cool.

In regular work the charges consist of roasted concentrates with fines from first-class ore. The charge is collected above the furnace in 5 to 7 hoppers having charge-pipes with gates or slides. In the non-regenerative furnaces the fire is at one end; consequently the larger part of the charge is dropped near the fire-bridge as follows: Beginning at No. 1 hopper nearest the bridge, 7½ parts will be charged; at No. 2, 6½ parts; at No. 3, 5 parts; at No. 4, 3 parts, and at No. 5 (at the flue end) 1 part only. With a regenerative furnace of seven hoppers the charge would be first dropped through the end hoppers that it may flow towards the center, then through the central hopper and its two neighbors, and lastly through the two remaining ones, the flow being regulated by the gates so that there may be a regular distribution.

As the charge melts down it is stirred at intervals that any lumps may be broken up. When melted and thoroughly liquefied the slag is skimmed to a settler. Zincky ore needs a strong finishing heat to insure a good settling of the zinc-bearing matte. The overflow from the settler is collected in tilting slag cars having pots of 5 to 6 tons capacity. The cars are hauled to the dump and poured. Another way of removing the overflow slag is by granulating it with water.

With a converter plant in connection, only a part of the accumulating matte is removed at a time, the aim being to keep the level as nearly constant as possible. With furnaces, the matte from which is intended to be shipped away, and where the furnace consequently is tapped dry, the tapping takes place only after several charges have been put through, and when 18 to 20 in. of matte has accumulated. Where the concentration is greater than usual as many as 12 charges have been smelted before tapping dry. In tapping the matte may be drawn off into sand- or cast-iron moulds, or else it may be tapped into a steel ladle and thence poured in the form of flat cakes. The furnace is now patched or fettled before dropping the next charge. With converter-plants fettling of the reverberatories is resorted to only once in 4 or 5 weeks, when of course the furnace must be tapped dry. Sand is generally used as fettling material. This has been at times replaced by a silicious gold ore. A furnace runs about three months before it must be shut down for repairs. Following is the analysis of flue-dust collected in the gas checkers of a regenerative reverberatory furnace: Insoluble, 91.1 per cent; SiO_2, 62.2 per cent; Fe_2O_3, 8.2 per cent; Al_2O_3, 25.7 per cent; CaO, 1.8 per cent; MgO, 0.0 per cent; S, 0.3 per cent; CuO, 2.3 per cent. Evidently considerable coal ash is carried over by the gases.

Converting Copper Matte.—A charge for a converter is tapped from a blast-furnace forehearth or from a reverberatory furnace into a steel ladle managed by electric traveling cranes. The charge is then brought to the converter and poured into its spout. Ladles are commonly 5 ft. diameter by 3 ft. 10 in. high. They are lined with ordinary loam plastered on by hand, dried by an air current, then by a wood and coke fire, and afterwards 3 in. in depth of converter slag is poured in. These ladles are used both for slag and matte. A lining is good for 9.5 tons of copper. In converting, the charge of 50 per cent matte is blown to white metal, the slag skimmed and the metal then blown to coarse metal. With matte running less than 50 per cent copper, the charge is blown to white metal, skimmed and re-charged with 50 per cent matte, blown to the slagging stage again, and finally to coarse copper. This latter method is called doubling, whereby a larger amount of copper is produced in one blow. The coarse metal is either poured direct into shipping ingots or transferred to a refining furnace to be refined before casting into anodes.

In Montana practice the upright converter has been replaced in new plants by the barrel or trough converter. Of the two sizes, the smaller (in more general use) is 7 ft. diameter by 10 ft. 6 in. long. When newly lined it will take an initial double charge of five tons, while the final double charge just before relining would be as much as 12 tons of 50 per cent matte. The large-sized converter is 8 ft. diameter by 12 ft. 5 in. long, and will take an initial double charge of 10 tons and a final double charge of 20 tons. The barrel type of converter needs less blast pressure than the upright type (10 lb., as against 16 lb. per square inch). On the other hand the upright converter gives a firmer lining. A bottom-blown upright converter (13 ft. high by 7 ft. diameter, and with 16 three-quarter-inch tuyeres) has been tried. Fifty per cent matte was successfully brought forward to coarse copper and satisfactorily poured. The difficulty was that the bottom soon floated up, while the critical points were less easily discovered, and had to be watched with great care. The experience thus far gained shows that the converter is more quickly blown than the side-blown one, and the wear of the lining is more even. When the question of lining the bottom satisfactorily has been settled it is believed that side-blowing will be given up, at least with a large converter having an initial charge of five tons of matte.

Converters are placed in a single row and blown into projecting hoods connected to a main flue, which has a draft of 0.1 in. of water. The main flue ends in a dust chamber (temperature 370° C.), which is connected to a stack. The converters are either filled at the front direct from the ladles, or the matte arrives at the back in a ladle, and is poured into a lined launder that conveys it to the converter spout at the front. Converter-body linings last at the best no more than for 28 tons of matte; the caps last longer. For lining, a greenish granular sandstone is used at times without mixture for a bond. Its composition is SiO_2, 64.4 per cent; FeO, 7.6 per cent; Al_2O_3, 16.5 per cent; CaO, 1.1 per cent; MgO, 1.8 per cent; ignition loss, 4.7 per cent, and it crumbles on exposure to the air. Lining material of crushed quartzite, pugged with 5 per cent clay, gives a satisfactory mixture. It analyzes SiO_2, 88.6 per cent; Fe_2O_3, 3.1 per cent; Al_2O_3, 4.0 per cent; CaO, 1.6 per cent. A mixture consisting of lining sand, slimes from the ore-dressing works, and second-class ore is used. In composition it is: Insoluble, 82.2 per cent; SiO_2, 63.0 per cent; Fe, 5.9 per cent; Al_2O_3, 17.3 per cent; CaO, 1.5 per cent; MgO, 1.3 per cent; S, 2.1 per cent; Cu, 1.0 per cent; H_2O, 11.0 per cent; ignition loss, 4.1 per cent. Finally, a mixture for the body of converters consists of quartzite and slimes, forming a lining which analyzes SiO_2, 85 per cent; Fe, 3.3 per cent; Al_2O_3, 4.0 per cent; S, 3.0 per cent; Cu, 4.0 per cent; Ag, 12 oz. per ton. In some instances silicious gold ores have been worked in for lining material. The material for the cap is made more plastic than that for the body. It consists of body material into which has been worked 5 to 10 per cent of clay, mixed with more water. The loss of the lining is due even more to the mechanical wear than to corrosion, since the swash and violent movement of the liquid contents agitated by the air causes parts of the lining to break off, and this is especially observable in the barrel converter. The chemical wear of corrosion takes place mostly near the tuyeres, the mechanical wear at the opposite side near the top of the body. In an upright converter, 14 ft. 2 in. high and 7 ft. diameter, the bottom layer would be 22 in. thick, the side lining at the tuyeres 30 in. thick, opposite only 18 in. thick, at the top of the lining on the tuyeres side 18 in. and opposite 28 in. thick. In the horizontal converter, 10 ft. 6 in. long by 7 ft. diameter, the bottom would be 18 in. thick, consisting of 4 in. lining mixture, 4.5 in. brick and 10 in. of lining mixture. The sides would be lined with a 4.5-in. course of fire brick, special brick

6.5 by 6.5 by 4 in. being used at the tuyere level. The lining at the tuyeres would be 30 in., opposite 16 in.; at the top of the body the corresponding dimensions would be 20 ins. on either side. At the ends of the converter the dimensions are 16 in. thick at the bottom of the cavity, and 34 in. thick at the top of the body. The ends are not lined with brick. The lining is either tamped in by hand, or an air-drill is adapted for power tamping. The ramming is done by contract, with a premium or penalty, according to the output of copper on that lining. The lining in operation is sometimes patched as follows: The vessel is emptied, cooled with water from the outside, the lining or other fusible material thrown in, tamped down and slag thrown over the patch. Another way is to run in matte and permit it to solidify in the cavity. A partial success has resulted from pouring in silicious blast-furnace slag, with the hope that the excess of silica, over that of the normal converter slag, would combine with the iron oxidized from the matte. The average time for converting a charge in the 5-ton upright converter (7 ft. diameter by 10 ft. 6 in. long) is 2 hours 55 minutes, or, excluding the time of pouring and of waiting for charges, 2 hours 20 minutes. The blowing of a single charge to white metal takes 47 minutes, double charge 82 minutes. The following table gives some partial analyses of products obtained in smelting:

	Cu.	SiO_2.	FeO.	Al_2O_3.	CaO.	Ag. Au. Oz.	S.	As and Sb.
Slag	2.0	30.0	55.2	9.5	1.0	....	....	....
"	1.6	29.8	57.8	10.0	1.0	0.8	....	....
"	5–6	31–32	54	....	....	....	....	....
Dust	37.8	1.5	7.4	1.9	None.	....	14.3	4.8
"	63.4	3.8	12.8	....	....	53.8	16.0	....
"	65	....	....	....	....	....	....	....
Pig-copper	99.0	....	....	....	....	9–40	....	....

The labor per shift for an upright converter is 1 skimmer, 1 puncher, 1 helper and 1 sampler. Three horizontal converters running as steadily as possible require 1 skimmer, 2 punchers, 2 helpers and 2 samplers.

In the following table further particulars of converters are given:

Converter.	Grade of Matte.	Hor. Section at Tuyeres.	Lining Material per Conv'rt'r	Lining per Ton Copper Result'g.	Copper per Converter on 1 lining.	Tuyeres.		Maxim'm Pressure.
	Cu %	Sq. Ft.	Tons.	Tons.	Tons.	No.	Diam.	Lb.
Upright vessel, 7 ft. x 14 ft. 7 in.	51.1	7.07	7.63	.53	14.8	8	¾	18
Medium barrel, 7 ft. x 10 ft. 6 in.	51.7	6.66	8.40	.32	26.2	14	¾	12
Large barrel, 8 ft. x 12 ft. 6 in.	45	17.79	16.60	.80	20	18	1⅛	15

It will be noticed that the medium-barrel converter uses up much less lining material per ton of copper obtained. This is due to the more silicious character of the lining of the former vessel, as well as to its lower content of iron. The clay used in linings has value only in making them plastic, and hence is used as sparingly as possible. The larger barrel converter uses up more lining material than the smaller one, owing to the lower grade matte which it puts through. In the upright converter the amount of free air used per ton of copper converted is about 200,000 cu. ft. displacement, equivalent to 160,000 cu. ft. at the sea level.

Extraction.—When treating an ore assaying 10 to 12 per cent Cu and 4 oz. Ag per ton, the recovery is approximately 92 per cent of the copper and 95 per cent of the silver.

Wet Methods at Rio Tinto, Spain.—(By Charles H. Jones, Santiago de Cuba.[9]) The well-known method adopted for the extraction of the copper consists simply in allowing huge heaps of the mineral to oxidize under the influences of air and moisture, and subsequently washing out the copper sulphate as soon as it is formed, by running water through the heap. When the copper occurs in the form of chalcopyrite, $CuFeS_2$, or as covellite, CuS, oxidation proceeds very slowly. The best form is chalcocite, or copper glance, Cu_2S, which with pyrite, FeS_2, constitutes the bulk of Rio Tinto sulphide. When the mineral is exposed to the air, ferrous sulphate is formed in accordance with the following reactions:

(1) $FeS_5 + 7O + H_2O = FeSO_4 + H_2SO_4$, and the ferrous sulphate is easily oxidized in contact with the air to ferric sulphate.

(2) $2FeSO_4 + H_2SO_4 + O = Fe_2\,(SO_4)_3 + H_2O$.

It is due to the action of the ferric sulphate on glance that the contained copper is rendered soluble, as follows:

(3) $Fe_2\,(SO_4)_3 + Cu_2S = CuSO_4 + 2\,FeSO_4 + CuS$.

(4) $Fe_2\,(SO_4)_3 + CuS + 3\,O + H_2O = CuSO_4 + 2\,FeSO_4 + H_2SO_4$.

The reaction (3) is fairly rapid, causing about half of the copper to go into solution in a few months; the reaction (4) proceeds much slower and requires, under favorable conditions, about 80 per cent of the remaining half of the copper.

The method of working is as follows: A site is chosen where the ground is sufficiently sloping and concave to enable the copper solution to collect and run out at one side of the heap, which contains approximately 100,000 tons. On the ground is first arranged a network of air-flues made of rough stones and about 12 square inside. At 50 ft. distant from one another, vertical chimneys, also of rough stones, are built connecting to the flues. Care must be taken that the mouths of the flues do not get covered by the overlying ore. The ore is crushed to not larger than 2 to 3 in., and the lump ore and fines are separated. The ore is now tipped from side-tip wagons (mine cars?), at the highest part of the site, over and around the stone flues. Lump ore and fines are alternately dumped until the height of the pile is 30 ft., the upper

9 *Transactions* American Institute of Mining Engineers, February, 1904.

surface of the pile being kept level. As the mineral is added so the chimneys are built up through the ore. The surface of the heap is formed into squares by means of ridges of the mineral, the size of the squares depending on the porosity of the heap. These squares are to ensure the more even distribution of the water over the heap and to prevent its running into channels. Gutters are also provided to conduct the water to all parts of the surface of the heap. As the heap is being formed, water is run on, and the copper sulphate already existing in the mineral extracted. Oxidation also starts as the result of the wetting. The completed and wetted heap begins to oxidize pretty rapidly, as shown by the heat produced, the temperature in the chimneys rising to 80° C. As the temperature rises, the surface openings of the chimneys should be closed to allow oxidation to spread through the heap. The surface gradually assumes a brownish coloration, due to dehydration of the basic ferric salt, which forms on top of the mass, and the gradual heating up may be noted by this drying action. The greatest care must be taken to prevent the heap firing. When oxidation has proceeded as far as it safely may, water is run on at the rate of 220 gallons per minute, until the soluble copper salts are leached out. The heap is again allowed to oxidize and the washing repeated. After about a year the surface needs 're-tilling' and the squares are arranged where the ridges formerly were, and the gutters are also shifted. At the edge of the heap, for a distance of some yards, the ore, which has become cemented, holds much copper salts, and is here dug down into terraces in order that this copper may be also extracted by washing. When there remains but 0.3 per cent copper in the heap, it may be considered washed, and the mineral, containing 49.5 per cent sulphur, is shipped away to be utilized in the manufacture of sulphuric acid. Successful heap-washing depends on the effieient ventilation of the mass, the trouble usually being an excess of fines, which cement together and clog the air passages.

The copper liquor which runs from the heap contains ferric iron, which is objectionable, and has to be removed by running it over a smaller heap or filter bed of fresh mineral, which reduces the ferric iron. This bed is placed within a reservoir formed by a masonry dam across a small ravine. The solution, after percolating the material, remains in contact with it until it is drawn off to the precipitating tanks. The solution contains Cu, 0.4 per cent; Fe_2O_3, 0.1 per cent; FeO, 2.0 per cent; free H_2SO_3, 1.0 per cent, and As, 0.03 per cent. The large quantity of FeO and H_2SO_4 present is due to the fact that a part of the waste liquor from the precipitation tanks is pumped back and used, together with fresh water, for watering the heaps, so that the solutions tend to concentrate.

The liquor at the reservoirs is run at the rate of 1,300 gallons per minute through the cementation tanks over pig iron in order to precipitate the copper in the form of a cement copper or copper precipitate. These cementation tanks are arranged upon the slope of a hill, the liquor passing back and forth through the tanks, until discharged from the lowest tank of the series free from copper. Each series consists of three tanks in parallel, arranged so that the liquor may be divided and passed along as many tanks as necessary, that depending both on the quantity and upon the temperature of the liquid, which in summer reaches 100° F. The tanks are 320 ft. long, 5.5 ft. wide and 2.25 ft. deep; their grades vary from 0.2 per cent, increasing to 1.1 per cent at the end, the reason being that as the solution becomes poorer in copper the free acid present becomes more active in dissolving the pig iron, and hence must be made to run away more rapidly by increasing the slope of the tanks.

The tanks or boxes are made of 9 by 3-in. plank, the spaces between the tanks being filled in. No metal is used in this construction, but the planks are pegged with hard-wood pegs. The planks are calked with oakum and pitched over to make the tanks water-tight. Any tank may be cut out by means of a slide gate at its end; a plug is then drawn and the liquor run to settling tanks, any copper in suspension being there recovered. This 'salida,' still containing 0.0015 to 0.002 per cent copper, is run to waste, for the reason that, with this copper content, the iron needed to recover the copper about equals in value the copper so recovered. Some of the tanks are cut out and cleaned daily, the liquor meanwhile passing through the other tanks. All the iron is removed from the tank and piled on the dividing wall, the copper adhering to the iron being meanwhile knocked off and thrown back into the tank, while the pig iron is piled on the wall. The dirty-looking precipitate is now removed to the cleaning and concentrating plant, while the pig iron is piled back upon old planks placed in the bottom, being stacked in open order. The liquor is then turned through the tank again. The crude precipitate, containing about 70 per cent copper, is gradually worked over and through a perforated copper plate placed at the head of a launder by means of a strong stream of water from a small nozzle. The oversize of the screen, consisting of leaf copper and small pieces of iron, is thrown into a heap and picked over by girls, who remove the scrap iron. The fines which pass the screen are turned over against a stream of water and concentrated. The heads of the launder for a few yards contain a red precipitate, known as No. 1 precipitate, containing Cu, 94.0 per cent; As, 0.3 per cent; then comes No. 2 precipitate of 92.0 per cent Cu and 0.3 to 0.75 per cent As, followed by No. 3 precipitate, in a very fine state of division, and containing 50 per cent Cu, 5.0 per cent As, all the graphite of the pig iron, and the bulk of the bismuth and antimony which has come from the liquors. Nos. 1 and 2 precipitates are dried under a shed and sacked for shipment; No. 3 precipitate is removed, moistened with acid liquors, made into balls by hand and dried in the sun to a hard cemented form. They are added to a blast furnace matting charge and the matte is converted, thus removing a large portion of the impurities (As, Sb and Bi).

The reactions of the precipitating tank are as follows:

(5) $Fe_2 (SO_4)_3 + Fe = 3 Fe SO_4$.
(6) $Fe + Cu SO_4 = Fe SO_4 + Cu$.
(7) $Fe + H_2SO_4 = Fe SO_4 + H_2$.

The first reaction causes a consumption of iron without a corresponding yield of copper, and should be avoided as far as possible by getting the iron in the ferrous state. The second reaction is electrolytic, and the final one, evinced by the rising bubbles of hydrogen through the liquor, also causes a wasteful consumption of iron.

While the liquor is fairly strong in copper, that metal is mostly precipitated in coherent form, but later, as it gets weaker, the precipitate becomes powdery, a condition conducing to increased galvanic action on the iron, and causing an increased precipitation of arsenic and of other impurities. At this later stage also the reaction (7) becomes proportionately greater, so that we may say the consumption of pig iron varies inversely as the strength of the liquor in copper.

By keeping down the amount of ferric iron in the liquor as far as possible, and by giving it a sufficient velocity through the tanks, even when strongly acid, it will not consume more than 1.4 per cent. pig iron to 1 per cent. Cu precipitated.

New Flues and Stack at Anaconda.—A most efficient and successful system of flues was built in 1903 at the works of the Washoe Copper Company, Anaconda, Montana.[10] Four flues—the blast furnace flue, the roaster flue, the reverberatory flue and the converter flue—each start from the building from which it takes its name and unite in a common flue. This common or main flue is 2,322 ft. long and terminates in a main stack 300 ft. high, erected on a hill 427 ft. above the roaster building floor.

The blast-furnace flue, starting from the blast-furnace dust chambers, is 1,653 ft. long, and is in part built through a solid rock cut. The flue is 20 ft. wide inside and 15 ft. high, the side walls being two full brick thick (17 in.) for half their height, and then one and a half brick thick for the remainder. The roof consists of transverse 7-in. I-beams, 22 ft. long, between which are set curved corrugated sheets of No. 20 iron, 4-in. spring, laid without lap and forming a center for a 4-in. brick arch, the entire roof then receiving a thin cement coating. The reverberatory flue, 842 ft. long, is of the same construction, except the roof, which is built of 56-lb. rails, laid transversely with 9-in. centers, to take a course of brick between the webs. The roaster flue, 488 ft. long, runs for a part of the way adjoining the reverberatory flue, with a 17-in. party wall between, and is of the same construction and dimensions as the reverberatory flue. The converter flue, 8 ft. by 8 ft. inside dimensions, is of the same construction as the reverberatory and roaster

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10 The Engineering and Mining Journal, December 24, 1903.

flues, and connects into the roaster flue. These flues require an excellent roof construction on account of the hot gases which they convey.

Of the 2,322 ft. of the main flue, 1,200 ft. is a single flue 60 ft. wide, and having a hopper or V-shaped bottom. Its side walls are 20 ft. high, and from them the bottom slopes at an angle of 30° towards the roof of a tunnel cut out in the bottom. At every 10 ft. along the roof of the tunnel are openings to draw off the flue-dust as it accumulates. It is expected that the flue-dust will slide down toward these openings. The total area of the flue is 1,600 sq. ft. The roof of this flue is constructed on the same plan as the blast-furnace flue. There are transverse 7-in. I-beams spaced 40 in. between centers, supported by 15-in. I-beam stringers, and these again resting on 12-in. I-beam columns, 28 ft. long, spaced 20 ft. between centers. In the remaining distance to the stack the flue is of double section, each 60 ft. wide, with a party wall, the only difference in construction being in the roof, which is made of ⅛-in. steel plates, riveted on top of the 7-in. I-beams by $^5/_{16}$-in. rivets, spaced 4 in. apart. This metal roof and extra width of flue is to cool the gases, lessen their velocity and facilitate in this way the separation and precipitation of flue-dust and arsenical fumes.

The stack, 300 ft. high, is of 30-ft. minimum diameter, and in this dimension the largest in the world. The sub-base of concrete, 6 ft. thick and 48 ft. sq., is founded on the solid rock. The base of the stack is 44.5 ft. square, with an inside diameter of 31.33 ft. up to 145 ft. in height. Thence it diminishes gradually to the top, where it is 30 ft. in diameter. The base is carried up 44 ft. to allow for openings on the opposite sides, where the flues connect. From the top of the base the circular stack begins with a 55-in. wall, becoming 12.5 in. thick near the top, where it swells out for the bell top. The whole is terminated by a cast-iron top, made in sections and filled with concrete. For the first 40 ft. of stack, cement-mortar 1:5 is used; for the remainder a lime cement-mortar with one-sixth cement.

To handle the flue-dust made, a small hoisting plant is put immediately behind the stack, consisting of a drum placed opposite each tunnel on a common shaft, which is geared direct to a motor; the cars on one side of the double flue being handled in balance with the other. From the point where the double flue merges into the single flue, down to the beginning of the single flue, a three-rail system is used, in order to avoid the use of switches. The cars to handle the dust are made with a sliding outlet pipe, and so arranged that a canvas bellows connection can be made with the hopper in the roof of the tunnel, the dust being thus drawn into the car without being carried into the air. After drawing off from any one hopper, the cars are lowered to the lower end of the tunnel, where an elevator is ready to raise and transfer them to an arsenic refining plant, which was erected in 1903.

Blast Furnaces and Converters at Rio Tinto, Spain.—These are of the regulation modern type of construction as to the lower part, shown in THE

Mineral Industry, Vol. XI., p. 205. There are two blast furnaces, each 42 in. by 160 in., at the tuyeres.[11] The jackets are two tiers high, the lower jackets being 8 ft. 4 in. high. There are three jackets on each side, and one at each end hung to the deck beams. The side bosh amounts to 4.5 in., and the smelting column to 7 ft. The furnace is run with an open breast, and is tapped to a forehearth of 12 ft. diameter by 40 in. high. This forehearth will hold 35 to 40 tons of matte.

The converters are of the barrel type, 6 ft. 10 in. diameter by 10 ft. 6 in. long, and have 12 tuyeres each. The capacity newly lined is 3 to 4 tons; when worn, 8 tons. They are served by an 8-ton ladle.

Smelting at Mt. Lyell, Tasmania.—There are five furnaces in operation.[12] The three large furnaces at No. 2 plant, which smelt the ore to first matte, are 42 in. by 210 in. at the tuyeres, have a height of ore column of 9.5 ft., and have 40 tuyeres 3 in. in diameter. Two furnaces at No. 1 plant concentrate the first matte to converter matte. They are 40 in. by 168 in. at the tuyeres, have a 9.5-ft. ore column and have 32 tuyeres 3 in. diameter. The furnaces are water-jacketted high up, the jackets being of cast iron. These large furnaces average 270 tons of ore daily, with an occasional output of 350 tons of pyrite ore. The average of the pyrite ore goes: Fe, 40.3 per cent; SiO_2, 4.4 per cent; $BaSO_4$, 2.5 per cent; Cu, 2.35 per cent; Al_2O_3, 2.0 per cent; S, 46.5 per cent. The present large outputs are due to an abundant supply of air blast, which reaches a pressure of 30 to 34 oz. at the furnaces. The furnaces are operated with hot blast stoves, fired with wood, and giving a blast temperature of 305° C. There are eight stoves, four in No. 1 plant with 56 cast-iron U-tubes each, and four in No. 2 plant with 70 tubes each. These stoves have given practically no trouble for repairs, there having been only a dozen tubes replaced since the beginning on account of burning out.

The blast is furnished by nine No. 8 Root blowers of 116 cu. ft. displacement, direct coupled by means of a flexible coupling, also by a No. 7 Root blower and two reserve No. 7 Root blowers, belt-driven.

The grade of first matte does not exceed 15 per cent Cu, being a concentration of about 6 into 1. The concentration of the first matte raises it to 50 per cent for converting. The quantity of coke needed for both blast furnace operations is 5 per cent calculated on the ore, or 3.25 per cent calculated on the materials of the charge. The coke as used is fed along the side walls of the furnace, that by its action it may prevent the furnace from getting too hard. The charges in ore smelting and in concentrating vary somewhat, limestone being used only in the latter case. The blast furnace slag varies within the following limits, viz.: Silica, 36.66 to 41.70; ferrous oxide, 50.67 to 43.40; lime, 1.20 to 8.16; baryta, 1.90 to 0.16; alumina, 7.47 to 5.46; copper, 0.25 to 0.35.

The flue-dust is ground and mixed in a pug mill, with 4 per cent common clay a little moistened, and no lime is used. The briquettes, like ordinary

11 *Iron and Coal Trades Review.* 12 *Report* of Secretary of Mines, Australia.

bricks in size, weigh 14 lb. each and are hand-moulded. They are dried on shelves, drying being hastened by slag-pots set close by. The flue-dust thus recovered amounts to about 1.3 per cent of the total charge. Its composition was: SiO_2, 33 per cent; Cu, 3.5 per cent; Ag, 2.5 oz. per ton; Au, 0.07 oz. per ton.

The slag is granulated and is elevated to be run to the tailing-dump by means of a steam-driven centrifugal pump. The pumps have a 10-in. suction and a 9-in discharge, with 18-in. vanes, and are run 540 to 600 r. p. m. The quantity of slag elevated during the year was 170,000 tons at No. 2 plant and 40,000 tons at No. 1 plant, being about 60 per cent of the charge. The respective lifts are 15 and 11 feet.

The converter plant is a double one, either half capable of turning out 25 to 40 tons of copper daily. There are 14 shells and 6 stands. The two remelting furnaces are each run with a No. 5 rotary blower. For the converters there are two Fraser & Chalmers horizontal compound condensing engines, 16 in. and 24 by 30 in., with air cylinders 30 by 30 in. delivering 3,000 cu. ft. of free air at 60 r. p. m. For the hydraulic operation of the converters is provided a 3.5 by 10-in. duplex Worthington high-pressure pump and an accumulator. The average blast pressure at the vessels is 8 lb. to the square inch. The converter lining is made from screened fines, from the quartz-crushing plant at the quarries, mixed with a fine white clay. A lining will last five to seven blows. The Stahlman type of square converter is used. An average assay of the blister copper gives: Cu, 98.83 per cent; Ag, 81.36 oz. per ton; Au, 3.124 oz. per ton. The converter matte assays: Cu, 49.48 per cent; Ag, 39.34 oz., and Au, 1.480 oz. per ton. The blister copper is cast into plates 16 by 24, by 2.5 in. thick, weighing 200 lb. Sampling is done by drilling two 3/8-in. holes in each plate. The copper is shipped to the Baltimore Copper Smelting and Rolling Company, Baltimore, Md., for refining, on a toll arrangement, the products being turned back to the company for sale. The products are electrolytic copper and fine bars of gold and silver.

A note from Mr. Alfred Miller gives this additional information: Ore smelting at No. 2 plant has been continued since November, 1902, without the use of coke, but with heated blast. At No. 1 plant, ore and matte are smelted with coke as before, but with cold blast. These changes have been made with no trouble, and may now be considered as permanently established, and have resulted in a slightly increased tonnage; and a considerable economy of operation. Four furnaces are now doing the work formerly accomplished by five, three of the furnaces being constantly on ore, and the fourth concentrating the first matte into converter matte.

The costs for the company's half year ended September 30, 1902, were as follows: Mining, $0.5002; removal of overburden, $0.50; smelting, $3.3648; converting, $0.3612; total, $4.7262. During the half year there were treated 159,450 tons of Mt. Lyell ore averaging: Cu, 2.36 per cent.;

Ag, 2.23 oz. per ton; Au, 0.069 oz. per ton, together with 18,537 tons of metal-bearing fluxes of an average value of Cu, 1.70 per cent; Ag, 0.24 oz. per ton: Au, 0.026 oz. per ton, and 5,689 tons purchased ore, making a grand total of 183,676 tons.

Pyrite Smelting at Sulitelma, Norway.—This consists in smelting raw ores in a converter lined with magnesite.[13] The tuyeres are set at the back, but close to the bottom. The red hot converter is charged with 90 lb. of coke to a little above the tuyeres. When the coke is burning the charge of 7.5 tons of ore and slag is added, and the blast is turned on with a pressure of 5 lb., slowly increasing to 10 to 15 lb. A very powerful action sets in at once, and by ten minutes slag is to be seen before the tuyeres. When the smelted ore covers the tuyeres the air pressure is increased to 20 lb. The charge now melts down, the sulphide melting first and then the slag-forming elements, this operation taking 1.5 hours. At this point the copper begins to concentrate, so that in 1.5 hours a 40 per cent. matte results, while in an additional half hour the matte has been carried to 60 to 70 per cent. copper. With the charging, tapping and cleaning the total time per charge will be 4.5 hours. The ores smelted at Sulitelma are sulphides containing: Cu, 8 per cent.; S, 32 to 34 per cent.; Fe, 34 to 36 per cent.; Al_2O_3, 2 to 4.5 per cent. The process has been tried upon quite a range of sulphide ore, and not only on lump ore, but also on mixtures of lump ore with sand and slime. The loss at present, is 0.6 to 0.9 per cent. copper. The converter is narrow and tapering at the bottom. The charge of 7.5 tons needs 160 h.p. for the compressor.

The costs in Norway are given as follows:

	40 Tons in 24 hrs.	Per Ton.
Wages	$14.47	$0.362
Power	5.67	0.142
Coke (528 pounds)	2.27	0.057
Magnesite brick	10.80	0.270
Amortization and interest	5.40	0.135
Supervision	0.07	0.002
	$38.68	$0.968

Smelting Practice at Washoe Smelter, Anaconda.—In starting this plant many irregularities and troubles occurred, such as are so often incidental to a new works.[14]

The ore-dressing works gave a product at first too high in silica for easy smelting. These concentrates were treated in McDougall furnaces, which had at first a draft so strong that a considerable portion of flue-dust was made, high also in silica. Again, with such a draft, and the consequent abundant supply of air, the ore was over-roasted, so that there was much ferric oxide formed; and in consequence, when this product was fused in

13 Knudson, The Engineering and Mining Journal, May 12, 1904.
14 R. L. Lloyd, The Engineering and Mining Journal, May 5, 1904.

the reverberatory, it gave a red rather than the usual green color to the slag. The silicious flue-dust, already mentioned, was collected in quantity, and charged to the reverberatory as forming part of a charge. Owing to its silicious character, and to its not being mixed with the remainder of the charge, its sulphide portion was easily melted out, leaving a silicious skeleton, which frequently stuck to the borders of the furnace, and had to be barred off.

Care should be taken to keep the reverberatory furnaces tight by accurately closing and claying up all cracks and apertures where any air can be drawn in. These cracks should be looked for at the roof, the doors and at the sides of the furnace. Variations in the performance of the furnaces were also due to the coal used; since when the coal bins were nearly empty the coal was poor, while with full bins there was a greater proportion of lump coal. The time of grating also varied with the coal; with good coal the time was 20 to 35 minutes, but with poor coal as high as 105 minutes was necessary. The under-grate pressure also varied with the coal used; with good coal this pressure was no more than 0.5 in. water, while the poor coal needed an under-grate pressure of 2.0 in. of water. Ordinarily these pressures were 1.0 in. water.

The air tended to pass up more freely at the corners of the fire-box, so that its supply was uneven. Hence there would be a clear flame along the sides of the furnace, and a smoky one at the center; at the sudden turn of the outlet flue the flames became mixed and the smoky flame, thus getting additional air, made a very hot flue and dust chamber.

With sufficient draft, no trouble has resulted from using boilers in connection with these reverberatories for utilizing the heat of the waste gases; indeed in one case, where the draft of the stack was too great, the impedence due to the boilers corrected the trouble.

Electrolytic Refining of Copper in Montana.—The works at Great Falls and Anaconda treat the anodes by the multiple-series method, but under different conditions for power.[15] At Great Falls there are three series of 104 tanks each, while at Anaconda there are seven series of 200 tanks each. At the former place each tank holds 20 anodes and 20 cathodes, with a current of 20 up to 40 amperes per square foot of cathode area, while at the latter each tank holds 76 anodes and 80 cathodes, while the current is only 10 amperes per square foot.

The anodes coming from the Butte district assay: Cu, 98 to 99 per cent.; Ag, 40 to 120 oz. per ton; Au, 0.1 to 1.5 oz. per ton. Anodes intended for refining at Great Falls are cast direct from the converter as follows: The molten copper, pouring from the converter, strikes a launder, which conveys it to a series of moulds having copper sides, but heavy cast-iron bottoms. These bottoms take the first corrosive action of the molten metal. The moulds

15 H. O. Hofman, *Transactions* American Institute of Mining Engineers, February, 1903.

are laid on a car, which is slowly moved beneath the stream. This coarse copper contains: Cu, 99.27 per cent; As and Sb, 0.07 per cent; Ag, 61.14 oz. per ton, and Au, 0.22 oz. per ton, and yields in refining 8 per cent of scrap and an anode mud that, after passing a 40-mesh screen, washing and drying, contains: Cu, 41 per cent; Ag, 7,000 oz. per ton, and Au, 18 oz. per ton. Since considerable SO_2 still clings to the copper, and is set free in the pouring, the surfaces of the anodes become quite rough. Such anodes are less evenly corroded than are the refined ones. They give more scrap and furnish an anode mud of a lower grade. For Great Falls practice, however, where power is cheap, it is considered more profitable to omit the refining operation. At Anaconda, where stream power must be used, the converter copper is refined. The several charges of converter copper are poured into a reverberatory furnace, are there refined and poled, and then cast into neat smooth-looking anodes, which are well suited for refining. The older way of rabbling the copper has been replaced by air-rabbling, or blowing a stream of air into the molten metal through 1-in. wrought-iron pipes inserted through the side and end doors. This uses up 6 ft. of pipe for a 40-ton charge. Two hours were formerly needed for rabbling; now the same work is done in one and one-quarter hours by blowing. Oxidation is continued until the small ladle shows the characteristic single bubble in the depressed center. The set copper is then poled to tough pitch. The anodes thus prepared are cast by means of a Walker casting machine. They yield upon refining only 5.5 per cent of scrap, while the 40-mesh anode mud assayed: Cu, 18 per cent; Ag, 15,000 oz. per ton; and Au, 38 oz. per ton.

The Great Falls anodes are 24 by 35, by 3 in. thick at the top, tapering to 2.5 in. thick, and bevelled on the bottom. They are suspended in the tanks by loops of copper rod of ¼-in. diameter, cast into the anodes when making. The anode weighs 500 lb., and is corroded in 18 days. The Anaconda anodes are 24 by 33, by 1.25 in. thick on the top, and 1 in. thick at the bottom, and are suspended from iron copper-covered cross-bars by means of ⅜-in. copper hooks. An anode weighs 230 lb. and is corroded in 37 days.

The cathode sheets are made in the usual way in extra tanks. At Great Falls they are 26 by 36.5 in. and weigh 2.5 lb.; they are suspended by the Morrow clip, which is fastened to the starting sheet by a machine that punches a star hole through loop and sheet, bends over the lugs and clamps them fast. The entire sheet therefore hangs in the electrolyte, whose circulation over the sheet is not impeded. At Anaconda the top edge of the starting sheet is clamped over the ends of a piece of sheet copper 4.5 by 11 in. There are four of these sheets to each cross-bar, each sheet being 11 by 33 in. and weighing 0.75 to 1 lb. The electrode distance is 1.5 to 2 inches.

The electrolyte with the 20-ampere current contains 17 per cent H_2SO_4 and 4.2 per cent Cu; with the 10-ampere current 15 per cent H_2SO_4, and 4.0 per cent Cu. When above 4.2 per cent Cu the resistance seems to increase. At the currents named the temperatures of the electrolyte are, respectively, 64° C. and 50° C., and the circulation six and three gallons of the electrolyte per minute. The solutions are admitted and drawn off either at the ends or at the sides, and, to prevent stirring up the anode mud, perforated lead baffle-plates are used. The various forms of plunger pumps formerly used for raising the electrolyte have given way to Pohle air-lift pumps, working under a pressure of 25 lb. per sq. in. (from a compressor). These pumps have proved satisfactory. The delivery pipe is cut in two and joined by a rubber hose, thus breaking electrical connection.

The electrolyte becomes enriched in copper and takes up iron, arsenic and antimony. A foul solution was found to contain: Cu, 5.18 per cent; Fe, 1.32 per cent; As, 1.402 per cent; Sb, 0.062 per cent, and H_2SO_4, 4.8 per cent. The low percentage of antimony is due to the fact that enough HCl is daily added at each head tank to maintain 0.004 per cent of chloride in solution. This addition precipitates the antimony as oxychloride. Where the HCl becomes insufficient, a sample plate suspended in the electrolyte becomes streaked, tarnished, black and brittle, showing that antimony has been deposited on the plate.

For purifying the electrolyte the following method is used: A portion of the electrolyte is diverted to tanks having lead anodes and using strong currents. The impurities, chiefly arsenic and antimony, with considerable copper, are deposited more or less loosely upon the copper cathodes placed opposite the lead anodes. The precipitated metals partly hang on the cathodes and partly drop to the bottoms of the vats. The accumulated arsenical and antimonial mud, containing 40 to 60 per cent Cu, is cleaned out every two months, and the mud reduced to impure bars at a refining furnace. When the cathodes become encrusted, they are likewise melted down into cake or ingot copper and used as a lower grade casting copper. The electrolyte, thus purified, is re-standardized and returned to the circulation. It finally becomes highly charged with iron, so much so that it tends to interfere with the deposition and to blacken the copper. Only then is the refinery solution withdrawn from the circulation and pumped to the blue vitriol works. Here, after crystallizing out the blue vitriol, the solution is evaporated to one-third its volume and then cooled, when most of the iron will crystallize out as green vitriol (ferrous sulphate).

At Great Falls the cathodes are renewed every second day, attaining by that time a weight of 53 lb. This frequent renewal uses up a large number of starting sheets, but is nevertheless profitable, since, if the cathode is allowed to become heavier, short-circuiting may occur. The 2-day sheets permit an ampere efficiency of 91 per cent, while with 4-day sheets the efficiency drops to 85 per cent. The cathodes are taken out, four at a time, by means of an overhead crawl and tackle, transferred to lead-lined cars, and replaced by starting sheets. Twenty sheets are thus collected on the car, are raised together from it by means of an electric crane, dipped into water, drained, dipped into milk-of-lime and allowed to dry. The lime coating protects the plates (in the melting-down operation) from sulphurous gases in the products of combustion of the refining furnace.

The following table gives the principal details of the electrolytic refineries:

DETAILS OF ELECTROLYTIC REFINERIES.

	Great Falls.	Anaconda.
Number of tanks	312	1,400
Length " "	9 ft. 9 in.	8 ft. 2 in. inside meas
Width " "	2 ft. 4 in.	4 ft. 5 in. inside meas
Depth " "	3 ft. 9 in.	4 ft. 6 in. inside meas
Number of tanks per set—*i. e.*, number of tanks using same solution	204	200
Number of anodes per tank	20	76
" " cathodes per tank	20	80
" " amperes per sq. ft. of cathode area	40	10
Power—		
Number of generators	2	7
" " circuits	3	7
Amperes generated per circuit	9,000	4,000
Volts per circuit	200	60
Character of material worked	Converter-anodes	Casting-furnace anodes
Kind of moulds used	Copper	Iron
Casting-machines, pattern	Walker	Anaconda
Converter-anodes, per cent Cu	99.1	....
" " " " As and Sb	0.07	....
" " oz. Ag	56.00	....
" " oz. Au	0.20	....
" " per cent scrap	8.00	....
" " mud, per cent Cu	41.	....
" " " oz. Ag	7,000	....
" " " oz. Au	18	....
Refined anodes, per cent Cu	99.27	99.25
" " " " As and Sb	0.07	0.10
" " oz. Ag	61.14	90.00
" " oz. Au	0.22	0.50
" " per cent scrap	5.5	7.00
" " mud, per cent Cu	18.00	10.00
" " " oz. Ag	15,000	18,000
" " " oz. Au	38.00	100.00
Size of anodes—		
Length	35 in.	32⅞ in.
Width	24 in.	24½ in.
Thickness	3 in., 2½ in.	1¼ in., 1 in.
Weight in pounds, converter	500	....
" " " refined	632	230
Number of days corroding, refined anode	....	37
" " " " converter-anode	18	....
Size of cathodes—		
Length	36½ in.	33 in.
Width	26 in.	11 in.
Weight of starting sheets, lbs	2½	¾, 1
Weight of cathodes, lbs	53	100
Number of cathodes on one bar	1	4
Electrolyte—		
Sulphuric acid per liter, grams	170	150
Copper per liter, grams	42	40
Temperature at head tank, C°	64	50
Circulation per minute, gals	6	3
Difference in potential—		
Soluble anodes, per tank	.6	.3
Insoluble " " "	2.5	2.
Composition of cathodes, per cent Cu	99.95	99.96
" " " " " As	.0012	.0009
" " " " " Sb	.0033	.0023
" " " oz. Ag	1.0	0.25

At Anaconda cathodes are removed only when the anodes are quite corroded; after two days' depositing they are taken from the vats, straightened and returned. A tank receives the anodes all at once; the cathodes are also removed together.

Treatment of the Anode Mud.—At Great Falls the thin mud is sucked out from the tanks by means of a hose and a steam injector pump, and straining into a settling-tank through a 40-mesh screen. Thence it is drawn to a pressure tank, forced through a filter press, steam-dried to 2 per cent moisture, broken up, sampled, sacked and sold.

At Great Falls the scrap that falls from the anodes and gets mixed with the anode mud is, after separation on the 40-mesh screen, returned to and remelted at the converter. At Anaconda it goes back to the anode furnace.

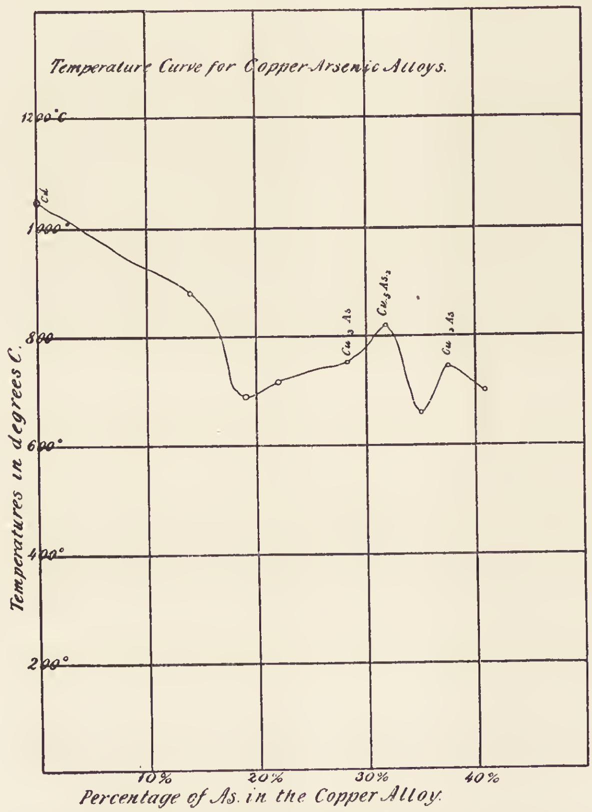

FIG. 8. DIAGRAM SHOWING INFLUENCE OF ARSENIC ON COPPER.

Refining at Cathodes.—The reverberatory furnaces have hearths 14 ft. 8 in. by 22 ft. 6 in., with an area of 225 sq. ft. The grate is 8 ft. 6 in. long by 7 ft. 1.5 in., or 60 sq. ft. area. The chimney is 32 by 32 in., and 80 ft. high. The furnaces take 75,000 lb. of cathodes to a charge. The ratio of charge to coal used is as 3 to 1.

In the oxidizing refining the rabbling is done by the use of compressed air, as already has been described. In poling, charcoal is also used. The cakes, ingots or wire-bars are cast by means of suspended ladles of either of two diameters, 14 in. and 19 in. The moulds are of copper. The cake and wire-bar moulds are painted before using with a wash of lamp-black and benzine; the ingot moulds are smoked before using by means of burning resin, held in a ladle. Tests of the copper give 96 to 97 per cent conductively, and a tensile strength of 65,600 lb. Three test-bars are taken per charge, at the beginning, middle and end of the ladling.

Costs in Electrolytic Refining.—Increasing current density increases the cost of power needed to precipitate a given weight of copper, but increases the output and decreases interest charges on copper locked up[16]. With higher temperatures of the electrolyte the resistances (and hence the power needed) decrease, but on the other hand we have to consider the extra cost of heating. To determine the conditions most favorable commercially a series of experiments were instituted involving these factors. A test was also made to determine the effect of covering the tanks as a guard against radiation. In estimating costs the three following items called "total costs" were taken into consideration: (1) Cost in kilowatt hours to precipitate a full-sized tank of copper of 5,700 lb. at $20.00 per horse power per annum. (2) Cost of heat needed to keep up the temperature of the tank. (3) Interest on the copper in the tank (6 per cent on $800).

From the table of costs we deduce the following:

Amperes per sq. ft.	At 50° C.	At 70° C.	At 90° C.
18.5	$0.95	$1.36	$1.79
27.7	0.91	0.90	1.19
37.0	0.95	0.82	0.89

The table just given refers to the series system. For the multiple system the costs similarly figured are as follows:

Amperes per sq. ft.	At 50° C.	At 70° C.	At 90° C.
18.5	$0.91	$0.83	$0.80
27.7	0.90	0.78	0.72
37.0	0.95	0.82	0.89

In the above labor is not included, and this item per ton of copper decreases inversely with the current density.

An analysis of the tests and the figures deduced shows: The results at 70° C. seem the most satisfactory at current densities, 27.7 to 32.0 amperes per square foot. Operating at this current density with covered tanks the current alone would be sufficient to heat the electrolyte to over 80° C. To maintain a good circulation, essential to a good deposition at these high current densities, pumping should be kept up. If the launders, carrying the so-

16 Wilder D. Bancroft, 'Electrolytic Copper Refining,' *Transactions* American Electro-Chemical Society, 1902.

lution to and fro, are properly covered, the solution need not drop below 70° C. before returning to the tanks.

At high current densities fewer tanks are needed to precipitate a given amount of copper, so that this diminishes the first cost of the plant. With covered tanks it will be possible to work in the tank room without discomfort.

If we compare the cost of working under usual conditions with open tanks using a current density of 14 amperes per foot and a temperature of 50° C. with that in covered tanks with a current density of 31.5 amperes and a temperature of 70° C., we will find the saving by the latter method to figure out very close to $1.00 per ton. Therefore, the author concludes that to refire most economically covered tanks should be used with a current density of 31.5 amperes per sq. ft., and at 70° C. temperature.

Property of Copper Near Melting Point.—Copper melts at 1,093° C. When within 200 or 300° of this temperature it becomes so brittle that it may be pulverized with a hammer.[17]

Properties of Copper Magnesium Alloys.—A series of these alloys[18] beginning at 90 per cent magnesium and 10 per cent copper, which fuses at 610° C., terminates at 10 per cent magnesium and 90 per cent copper, fusing at 890° C. Up to 75 per cent copper the alloys are white, brittle and remain fusible as at first. With more than 75 per cent the color becomes yellowish to copper color, and the alloy gradually increases in toughness.

Alloys of Copper and Arsenic.[19]—The influence of varying proportions of arsenic alloyed with copper is shown graphically in the accompanying table (Fig. 8). The microstructure of these alloys show, for those at the summits of curves, a structure composed of one substance made up of crystal grains having fine boundaries. Alloys belonging upon the slopes of the curve show a widening of these boundaries, the spaces becoming filled with a network of matter differing from the crystals and showing the striated appearance characteristic of the eutectics. As the bottom of the curves is reached the eutectic occupies the whole surface, presenting an extremely fine striated structure.

Copper Losses in Blast Furnace Slags.[20]—Wm. A. Heywood gives the results of numerous assays on slags in copper matte smelting. For slags containing 33 per cent SiO_2 he found that the slag retained increased progressively up to 0.35 per cent Cu, when the matte ran 25 per cent Cu. The amount thus retained with a matte of 50 per cent was 0.57 per cent Cu. With slags containing no more than 30 per cent silica the loss in these cases was about 0.10 per cent more than those given, being 0.45 per cent and 60 per cent, respectively. It is to be noticed also that the more silicious slags of 33 per cent

17 The Engineering and Mining Journal, February 28, 1903.
18 Von Boudouard, *Revue Industrielle*, November 29, 1903.
19 A. J. Hiorns, *Proceedings* of the Faraday Society, London, 1904.
20 The Engineering and Mining Journal, March 10, 1904.

silica were as fast running as the more irony ones of 30 per cent and less. The following is a complete analysis of an average slag: SiO_2, 31.0 per cent; FeO, 50.4 per cent; Al_2O_3, 4.8 per cent; CaO, 6.3 per cent; MgO, 1.4 per cent; S, 1.4 per cent; Zn, 2.0 per cent; Mn, 0.50 per cent, Cu, 0.45 per cent.

The Effect of Impurities on Commercial Copper.—The effect of single impurities on pure copper may be divided into three groups, according to their effect on the microstructure.[21] They are:

First group, metals that separate out in a free state from the copper crystals, as lead and bismuth.

Second group, metals and non-metals that alloy with a portion of the copper and separate out as an alloy, as arsenic, antimony, tin, zinc and the non-metals, oxygen, phosphorus and sulphur.

This group may be again divided into two, according as to whether or not the alloy separates into two or more constituents when solidified. Thus we have:

Division A, where the alloy separates into two constituents, giving—

(1) Copper and copper-antimonide.

(2) Copper and a copper-zinc alloy (Cu_2Zn).

(3) Copper and copper oxide (Cu_2O).

Division B, where the alloy remains united as a solid alloy or solution of arsenic, tin and phosphorus in copper.

Third group, metals that dissolve in the copper crystals, but which do not separate out and form a solid solution, as iron, manganese, aluminum and nickel.

Pure copper, when melted and cooled slowly, shows, under the microscope, after polishing and etching with ammonia, crystals with sharp fine boundary lines.

When pure copper is alloyed with 0.2 per cent Pb or Bi (first group) its microscopic structure shows crystals of copper surrounded with a thin skin of the alloying metal. These metals make the copper so brittle that it will not roll.

Pure copper containing 0.2 per cent As, P or Sn (second group, division B) shows crystals of copper in an irresoluble network. This copper, rollled hot, is very malleable.

Pure copper containing 0. 2 per cent Sb, Zn or O (second group, division A) shows a network containing two constituents. Of these impurities the two first cause the copper to roll poorly.

Pure copper containing 0.2 per cent Mn, Al or Ni (third group) does not show a network; indeed, manganese and aluminum, when present to 0.5 per cent, neutralize the effect of 0.1 per cent S, probably by holding it in solution. Arsenic tends to neutralize the injurious effects of bismuth, lead and antimony, while tin, manganese and aluminum only intensify them.

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21 *American Manufacturer and Iron World*, December 31, 1903.

When oxygen is present in copper it is in the form of cuprous oxide (Cu_2O), and there may be as much as 1 per cent without affecting malleability. This cuprous oxide unites itself to a farther portion of the copper, forming an eutectic alloy which is capable of holding impurities in solution. When too little of this alloy exists some of the impurity, as lead, will be present in the free state (over-poled copper); when too much of the alloy forms, the excess of cuprous oxide acts injuriously.

For boiler tubes four kinds of copper are now used: (1) Ordinary refined copper. (2) Arsenical copper. (3) Phosphorized copper. (4) Nickel or manganese copper (2 to 3 per cent Ni or Mn).

Ordinary refined copper should contain not more than 0.1 per cent Pb or As, not more than 0.05 Sb, under 0.005 per cent Bi, and have 0.1 to 0.2 per cent O to take care of impurities.

Arsenical copper is one of the best kinds for tubes and fire-box plates. It has a higher tensile strength at ordinary temperatures, and at 250° C. than ordinary refined copper; the copper arsenide neutralizes the bad effects of lead and bismuth, as already shown, and should be present to at least three times the amount of the last-named impurities, but oxygen should not exist to a greater amount than 0.1 per cent.

Phosphorized copper can be made only from a superior grade of copper containing no more than 0.04 per cent oxygen, and with phosphorus to the extent of 0.05 to 0.10 per cent.

Copper containing 2 or 3 per cent of nickel or manganese is harder than ordinary copper, and the tensile strength is increased. It must, however, be made with a high-class copper as, if made into tubes from lower-grade commercial copper, it is liable to crack.

COPPERAS.

The production of copperas in the United States during 1903 amounted to 20,240 short tons, valued at $121,440, as compared with 19,784 short tons, valued at $118,474, in the previous year. These totals do not include the quantity calcined for the manufacture of Venetian red and other pigments, but only the actual amount of copperas marketed as such.

The largest producer of copperas in this country is the American Steel & Wire Company, which operates plants in connection with the manufacture of wire at Worcester, Mass.; Cleveland, O.; Joliet, DeKalb and Washington, Ill. Among other producers in 1903 were the American Tin Plate Company, which took over the plant of the Forest City Manufacturing Company at Elwood, Ind.; the Pennsylvania Salt Manufacturing Company, with works at Philadelphia and Natrona, Pa.; C. K. Williams & Company, Allentown, Pa.; S. P. Wetherill Company, New Castle, Pa.; Stauffer Chemical Company, San Francisco, Cal.; International Nickel Company, Camden, N. J.; Atlantic Dynamite Company, Wilmington, Del.; Forcite Powder Company, Kenville, N. J., and Wickwire Brothers, Cortland, N. Y. Of the above concerns the American Steel & Wire Company, C. K. Williams & Company and S. P. Wetherill Company manufacture iron pigments from copperas. For details as to the methods used in recovering copperas from solutions reference should be made to THE MINERAL INDUSTRY, Vol. X.

An important feature in the copperas trade recently has been the extension of its use for water purification, a result of experiments carried on at Quincy, Ill. Several municipal corporations have replaced the more expensive coagulent alum with copperas, which is said to be equally efficient. The process as employed at Quincy involves the use of copperas and lime applied separately in small quantities in solution to the water. The iron is precipitated as ferrous hydrate in a flocculent form that favors sedimentation. Sufficient lime water must be added to neutralize the carbon dioxide present in the water and to unite with the iron of the copperas. The cost of the process varies somewhat with the turbidity of the water treated, ranging from $1.50 to $2.75 per million gallons.

FLUORSPAR.

Owing to the lessened demand for fluorspar in the iron and steel industries, and the large accumulation of stocks from the previous year, the output of fluorspar in 1903 showed a considerable falling off as compared with the production in 1902. The total amounted to 42,523 short tons, valued at $213,617, against 48,018 short tons, valued at $271,832, in the previous year. There were twelve companies engaged in mining operations, of which six were in Kentucky, four in Illinois and one each in Arizona and Tennessee.

PRODUCTION OF FLUORSPAR IN THE UNITED STATES. (IN SHORT TONS.)

Year.	Tons.	Value.	Per Ton.	Year.	Tons.	Value.	Per Ton.	Year.	Tons.	Value.	Per Ton.
1892..	9,000	$54,000	$6.00	1896.	6,000	$48,000	$8.00	1900.	21,656	$113,430	$5.24
1893..	9,700	63,050	6.50	1897.	4,379	36,264	7.65	1901.	19,586	113,803	5.81
1894..	6,400	38,400	6.00	1898.	12,145	86,985	7.16	1902.	48,018	271,832	5.19
1895..	4,000	24,000	6.00	1899.	24,030	152,655	6.35	1903*a*	42,523	213,617	4.28

(*a*) Statistics of the U. S. Geological Survey.

The production in 1903 was distributed as follows: Kentucky, 30,835 tons ($153,960); Illinois, 11,413 tons ($57,620); Arizona and Tennessee, 275 tons ($2,037). Of the total, 30,338 tons, valued at $129,971, were sold in the form of lump fluorspar, 5,235 tons, valued at $52,346, in the form of ground fluorspar, and the remaining 6,950 tons, valued at $31,300, were held in stock by the producers.

PRODUCTION OF FLUORSPAR IN THE PRINCIPAL COUNTRIES OF THE WORLD. (*a*)
(IN METRIC TONS.)

Year.	France.	Germany.					Spain.	United Kingdom.	United States.
		Anhalt.	Bavaria.	Prussia.	Saxony.	Schwarzburg.			
1898 ..	3,077	6,415	4,440	11,863	775	294	5	507	11,018
1899 ..	5,140	5,815	3,631	12,932	1,355	573	310	796	21,800
1900 ..	3,430	6,028	7,456	13,820	(*b*) 2,019	987	4	1,472	19,646
1901 ..	3,970	5,707	5,220	14,973	(*b*) 1,825	1,016	*Nil.*	4,232	17,768
1902 ..	2,650	(*c*)	5,460	14,273	2,947	(*c*)	93	6,388	47,190

(*a*) From the official reports of the respective countries except the United States, for which the totals are based on direct returns of the producers, and for Anhalt, Saxe-Weimar and Schwarzburg-Sonderhausen, which are due to the courtesy of Herr von Scheel, director des Kaiserlichen Statistischen Amts. (*b*) Includes 557 metric tons from Saxe-Weimar in 1900, and 210 metric tons in 1901. (*c*) Statistics not reported.

Market.—For the American market fluorspar is divided into six grades, namely, American lump No. 1, American lump No. 2, gravel, crushed, ground fine, and ground extra fine. The foreign product appears in two grades only—lump and fine.

The prices for fluorspar in the New York market ruled about as follows, per short ton: First grade lump, $14.40; second grade, $13.90; first grade gravel and crushed, $13.40; second grade, $12.40; first grade ground, $17.30;

second grade, $16.50. Foreign lump brought from $8 to $12, and foreign ground, $11.50 to $14.

The Uses and Technology of Fluorspar.

BY F. JULIUS FOHS.

Fluorspar, fluorite, or calcium fluoride (CaF_2) is composed of 48.7 per cent fluorine and 51.3 per cent calcium. It is found in nature admixed with various impurities, among which may be mentioned iron oxides, silica, calcite, etc. The commercial product carries from 60 per cent to 99 per cent calcium fluoride; the various grades being adapted to several specific uses. Fluorine, as is well known, does not combine with oxygen, but the facility with which it unites with other elements compensates for this in a measure, and gives to fluorspar many important applications in the arts.

The uses of fluorspar may be grouped under three heads: (1) The manufacture of hydrofluoric acid; (2) as a flux in metallurgy, also for the manufacture of opaque and opalescent glass and enamels, glazes and fireproof ware; (3) the manufacture of cheap jewelry, vases, etc.

The Manufacture of Hydrofluoric Acid.—Hydrofluoric acid (HF) is made by decomposing or distilling fluorspar with concentrated sulphuric acid in cast-iron vessels. The reaction involved is $CaF_2 + H_2SO_4 = 2HF + CaSO_4$. This reaction will take place at ordinary temperatures, although complete decomposition is effected only at 130° C. or above. The acid is evolved as a vapor. The gas dissolves in water with the evolution of considerable heat, forming the compound $HF + H_2O$. Commercial acid contains from 30 to 60 per cent water. Weak acids, containing from 30 to 35 per cent HF, are shipped sometimes in barrels, while the higher grades are marketed in lead or gutta percha vessels.

The principal impurity of hydrofluoric acid is fluosilicic acid, and it is most important that the commercial acid be almost free from this substance, as the value of hydrofluoric acid for most purposes depends upon the facility with which it combines with silica.

To make pure acids it is essential that manufacturers use fluorspar carrying only a small percentage of silica, less than one per cent at most. It is also advisable to use white fluorspar, since the colored varieties contain hydrocarbons which increase the impurity of the acid. The best grades are obtained from the deposits that occur in limestones containing only small quantities of silica and carbonaceous matter. Fluorspar mixed with carbonates are also undesirable. The main use for the acid is in etching glass. From 5 to 10 per cent of the fluorspar mined is consumed in the manufacture of acid.

Fluorspar in Metallurgy.—The use of fluorspar in metallurgy was first mentioned in 1529 by Agricola, who gave the mineral its present name (from Lat. *fluere,* to flow) owing to its quality of rendering slags fusible at a low heat. Silica, sulphates of lime and barium, and other refractory substances can be readily fused with fluorspar into homogeneous masses, but it shows little tendency to dissolve basic oxides. One part of fluorspar will liquefy about one-half part of silica, four parts of calcium sulphate or one and one-half parts of barium sulphate.

In the metallurgy of iron and steel fluorspar is used principally for the purpose of carrying the silica, sulphur and phosphorus into the slag. The phosphorus is converted in part into phosphorus fluoride, a colorless, inflammable, fuming liquid readily volatilized, and in part is carried into the slag as calcium phosphate. The use of fluorspar also effects a saving in the quantity of fuel necessary to reduction of the charge, perhaps by liberation of heat in the production of fluosilicate in the slag. According to Foehr, the reactions involved in the fluxing of the silica in iron ores, by the use of fluorspar and limestone respectively, are as follows:

$$2CaF_2 + 3SiO_2 = 2CaSiO_3 + SiF_4.$$

$$3CaCO_3 + 3SiO_2 = 3CaSiO_3 + 3CO_2.$$

The quantitative economy of the two fluxes is in the proportion of 156 to 300, but in practice the economy is often much greater than this, as one part of fluorspar at times goes further than ten parts of limestone.

The quantity of fluorspar used for flux in the United States in 1902 was only 0.36 per cent of the quantity of limestone flux consumed. The cost of fluorspar, f. o. b. mine, is from six to twelve times that of limestone at the quarry. This extra cost is compensated for in a measure by better quality of material produced, by a saving in fuel, an increase of from 3 to 5 per cent in iron output, by the greater fluxing power of the fluorspar and by the reduction of costs due to the payment of freight on, and the handling of, the less tonnage. With the assured supplies of fluorspar in the Kentucky and Illinois districts, which are accessible to transport by water and rail to the large iron and steel centers, it is believed that the use of fluorspar in iron metallurgy will show a constant increase in the future. Fluorspar for steel-making should not contain more than 3 or 4 per cent silica, while for ordinary irons or in foundry use, lower grades may be readily used.

Fluorspar is employed to advantage in the manufacture of ferrosilicon, ferromanganese, open-hearth and bessemer steels and also ordinary irons. An iron alloy containing as high as 10 per cent Si can be obtained in the ordinary blast furnace from a silicious iron ore if it be fluxed with fluorspar. The fluorspar energetically reduces the silica, or rather unites with it to form fluorsilicon, which is reduced to silicon by the hydrogen contained in the furnace gases and possibly, also, by the coke. Similarly in the manufacture of iron manganese alloys the use of fluorspar is an advantage, and in the manufacture of ferromanganese it is absolutely necessary.

In the open-hearth steel furnace fluorspar is used mainly in the basic processes to make a more fluid slag, also to prevent the slagging of the phosphorus and to reduce the sulphur content.

A small quantity of fluorspar may often be used to advantage in the smelting and refining of copper, reducing its arsenic and silicon content; in the separation of copper and nickel, the nickel being collected in the matte; and in the reduction of tin, etc.

Fluorspar in the Manufacture of Glass.—In general practice the opacity and opalescence of glass is secured through the use of cryolite, phosphate of lime, or fluorspar and feldspar. The use of cryolite in the manufacture of such glass is on the decline, owing to the high per cent of fluorine it leaves in the glass, which attacks the vessels in which the melt is made. The high percentage of phosphoric acid left in the glass by employing phosphate of lime is also undesirable. By employing fluorspar and feldspar the fluorine present in the glass is only about one-half as much as with the use of cryolite. Owing to this fact the use of fluorspar in the glass industry is constantly increasing. Opacity is dependent upon an evenly distributed suspension of an insoluble excess throughout the mass of the glass, and fluorspar, by its quality of producing very homogeneous masses, is especially adapted to its production. No. 1 ground fluorspar of the finest obtainable mesh is employed for this purpose.

Fluorspar for Enamels, Glazes and Fireproof Ware.—To produce enamels, fluorspar is used in combination generally with a refractory substance. It may be used as a flux in preparing the overglaze or colored enamels of porcelain ware. According to some authorities only colorless fluorspar should be employed for the purpose, owing to the belief that the coloring matter is of metallic character and would interfere with the metallic oxide used to produce the special shade of color sought for the enamel. This view, however, does not seem to be well founded, as the coloring matter of fluorspar is composed of hydrocarbons which are readily volatilized when subjected to the heat necessary to fuse the enamel. In the manufacture of enamels for casts and wrought-iron hollow-ware, fluorspar is now being employed as a flux, replacing a part of the carbonate of soda and boracic acid commonly used for this purpose. Fluorspar is used in small quantities in making fireproof ware, presumably for fluxing the materials more thoroughly, making them more homogeneous and dense, the fluorspar volatilizing when heated sufficiently in the kiln.

Fluorspar for Ornamental Purposes.—Fluorspar crystallizes in the isometric system, commonly in cubes, and has a perfect octahedral cleavage. It shows a wide variety of colors—white, yellow, green, violet, blue, brown, red, etc.—and the various colored varieties can be used for cheap jewelry settings. It cannot be classed, however, as a true gem, as it is brittle and is easily scratched. When flawless and pellucid it is valuable for certain optical and scientific purposes. The massive and coarse-grained varieties are made into paper weights, vases, etc. In making ornaments the fluorspar is first shaped from the lathe by a fine steel tool and is finished off with pumice and emery.

GARNET.

The production of garnet for abrasive purposes in the United States in 1903 was 4,413 short tons, valued at $146,955, against 3,722 short tons valued at $122,826 in the preceding year. A large part of the output in both years came from the New York mines situated near North Creek, in the Adirondack Mountains. The North River Garnet Company, of North River, Warren county, N. Y., and H. H. Barton & Sons, of Philadelphia, Pa., are the largest producers in this section. The National Abrasive Company, of Waynesville, N. C., and the American Glue Company, of Boston, Mass., also contributed to the output in 1903. The subjoined table shows the production of garnet for a number of years past.

PRODUCTION OF GARNET IN THE UNITED STATES.

Year.	Short Tons.	Value.	Year.	Short Tons.	Value.
1894....	2,401	$90,660	1899....	2,565	$72,672
1895....	3,325	95,050	1900....	3,285	92,801
1896....	2,440	85,400	1901....	4,444	158,100
1897....	2,261	66,353	1902....	3,722	122,826
1898....	2,882	82,930	1903....	4,413	146,955

GOLD AND SILVER.

BY T. A. RICKARD.

The output of gold in 1903 was the highest on record, aggregating a total of $326,566,926, which is about 13½ million dollars more than the previous maximum, in 1899. This valuation represents 15,803,920 fine ounces or 491,553 kilograms. The comparison between the world output of 1903 and that of the former record period, 1899, will emphasize the fact that the events in the Transvaal are mainly responsible for the fluctuations during recent years. In 1898 the Transvaal produced gold valued at $79,026,905, which would have been exceeded in 1899 had not the war supervened; in the closing months of that year military movements began to hinder mining operations, and they shortly ceased altogether, save for the robbing of the richer mines during the Boer occupation of Johannesburg. In 1901 work was slowly resumed under British rule, and in 1902 the declaration of peace permitted of a more active resumption of exploitation, so that the production rose to $35,250,155. In 1899 it was $76,535,820; in 1900, only $7,348,307; and in 1901, still less, $4,333,384. A marked expansion of energy, followed by the restarting of an increasing number of mines, characterized the year 1903; while 2,990 stamps were dropping at the end of 1902, there were 4,360 at work, out of a possible 7,145, in December, 1903. This resulted in a steadily augmenting monthly output, so that from a total of 196,023 oz. of fine gold in December, 1902, the production grew to 278,711 oz. in the corresponding month of the past year. As a consequence of the increase in the number of stamps at work the yield for 1903 was 2,963,681 oz. fine, valued at $61,259,281, which may be compared with the highwater mark of 1898, when the production reached 3,823,222 oz. fine gold, having a value of $79,026,905. It is expected that 1904 will come close to the previous high record. By reference to the special article on the progress of mining in the Transvaal, appearing elsewhere in this volume, it will be seen that all further advance depends upon the solution of the labor problem.

After continued efforts on the part of the mine operators, supported by the resident population, but opposed by a large party in England, it was finally arranged to introduce Chinese coolies under indenture, with proper safeguards as regards their segregation in compounds, assurance of sanitary conditions and eventual return to their own country. Since the close of 1903 this importation of labor has begun, with every promise of facilitating the opening up of idle mines and furnishing the one impetus most needed since the termination of the war.

In Rhodesia, to the north, the lack of native labor also has hindered mining operations, but to a less degree. The output for 1903 was 231,872 oz. bullion, equivalent to 196,682 oz. fine gold, valued at $4,065,436. This is the highest figure ever reached and compares with $3,573,822 in 1902. While exaggerated notions of the Rhodesian goldfields no longer pass current, the realization of facts has resulted in a systematic development of a number of small mines and the introduction of economies hitherto not attempted.

The leading gold-producing region to-day is Australasia, the output for 1903 having reached a total of 4,231,362 oz. fine gold, valued at $87,462,252, which is the highest on record since the days of placer mining forty years ago, when the alluvial deposits of Victoria astonished the world. In 1856 Victoria alone yielded 3,053,744 oz., valued at over $60,000,000. But that was the cream of easily exploited shallow gravels, concentrated by nature during preceding ages, and it was won by men with implements and methods which are in strong contrast to the expensive machinery and intricate operations involved in the mining of veins of gold-bearing quartz to a depth which now, at Bendigo, has reached 4,000 ft.

Western Australia is credited with nearly one-half of the total yield of Australasia, as the following statement indicates:

State.	Yield.	
	Fine Ounces.	Value.
Western Australia	1,979,299	$40,912,110
Victoria	767,351	15,861,145
Queensland	668,546	13,818,846
New South Wales	254,260	5,255,554
South Australia	22,269	460,300
Tasmania	59,891	1,237,947
New Zealand	479,746	9,916,350
Total	4,231,362	$87,462,252

Of the gain of $7,000,000 shown by the whole of Australasia, nearly one half is attributable to the increase from Western Australia. The remainder of the increase is shared by New South Wales, Victoria and Queensland, in the order named.

The history of gold mining in Western Australia during 1903 is eminently satisfactory, because it includes not only successful underground exploration, but a betterment in technical practice, with a resulting lowering of costs such as marks the best kind of mining. The magnificent proportions of the industry are due largely to a group of sixteen mines, which together contribute two-thirds of the total production of the State. They are chiefly identified with the Kalgoorlie district. There is reason to believe that these mines are likely to maintain their production for several years, because they have large reserves of ore. In 1903 the deepest workings, at 1,700 ft., made a good showing, and the gradual improvements in ore reduction, due to unremitting metallurgical investigation, promises a diminution in costs such as will render available a constantly increasing tonnage. This region has been, and is still, remarkable for the unusually high average tenor of the ore, namely, slightly over one ounce of gold per ton. Such a yield is more than twice the average content of the lode-matter treated in other regions and has been the chief stimulus to conquering the obstacles presented by an arid tableland in the inaccessible interior of the Australian continent; so that to-day a gigantic water system and numerous railways serve the needs of a mining region which 12 years ago was an unexplored desert.

In Queensland the Gympie district has undergone expansion, the year 1903 being further marked by the working of profitable gold ore at a vertical depth of 3,069 ft., in the West of Scotland mine. A similar interesting feature is presented by the old district of Bendigo, in Victoria, where the New Chum Railway mine struck free gold at a vertical depth of 3,876 ft., the deepest gold mining ever achieved by man. A neighboring mine, the Victoria Quartz, also found profitable ore at 3,814 ft. These explorations into the deep will encourage the miner all over the world, and will serve to balance the recognition of the fact that the superficial deposits are becoming rapidly exhausted.

This is true, in large measure, of the concentrations of gold in the placer deposits of Arctic America to-day, as it was true of California and Victoria fully thirty years ago. The bonanzas of the Klondike and Cape Nome have been fairly skimmed of their cream, but much good gravel still remains. During 1903 the Yukon territory yielded \$12,500,000, which was \$2,000,000 less than the year before, although it is proper to state that reliable statistics are difficult to obtain by reason of the amounts of gold carried out of the region in the effort to avoid the royalty levied by the Canadian government. On the other hand it is to be noted that the government devotes a part of this royalty to the construction of wagon roads, an important aid to all mining exploration.

Canada produced 911,199 oz. gold, valued at \$18,834,490, a slight decrease as compared to 1902, and mainly accountable to the falling off in the Yukon. Aside from the latter there is little to chronicle, for in British Columbia, with an output of 5,873,036, no important developments have taken place, the bulk of the gold coming from the low-grade copper-bearing sulphides of the Rossland district.

Mexico has helped the world-wide increase by producing \$12,550,000, as compared to \$11,293,524 in 1902. The gold output of our neighbor Republic exhibits a steady annual growth, and the information to hand regarding mining developments in the various States indicates that the advance will be maintained. The increase recorded is due in part to the opening up of districts hitherto almost inaccessible and to the impetus given by large investments of American and English capital, but it is traceable chiefly to the growth of the smelting industry of the country which affords an enlarged market for ore formerly considered as refractory.

In India there has been a large production, increasing from $9,683,798 in 1902 to $11,140,069 in 1903; this increase was largely due to the fine showing made by the Champion Reef mine, which paid dividends at the rate of 165 per cent for the year, on an output of 211,513 oz. gold extracted from 175,971 tons of ore. The Nundydroog mine also exhibited a noteworthy gain. These mines, and five others of importance, are situated in the Kolar goldfield, in

GOLD PRODUCTION OF THE WORLD.

Countries.	1902.			1903.		
	Fine Ounces.	Kilograms.	Value.	Fine Ounces.	Kilograms.	Value.
AMERICA, NORTH:						
United States	h 3,870,000	120,369.5	$80,000,000	h 3,560,000	110,727.5	$73,591,700
Canada	1,032,253	32,103.0	21,336,667	911,199	27,308.2	18,834,490
Newfoundland	4,000	124.4	82,680	6,844	2.112.3	141,477
Mexico (a)	546,373	16,994.0	11,293,524	556,887	17,321.0	11,511,530
Central America	95,571	2,976.4	1,975,000	90,711	2,821.4	1,875,001
AMERICA, SOUTH:						
Argentina	2,900	90.2	c 60,000	1,451	45.1	30,000
Bolivia	7,257	225.7	c 150,000	7,257	225.7	e 150,000
Brazil	146,898	4,569.0	3,036,381	110,014	3,517.8	2,274,000
Chile	27,827	876.8	575,200	32,172	1,000.6	665,000
Columbia	120,831	3,561.3	2,500,000	131,785	4,098.9	2,724,000
Ecuador	13,304	413.8	e 275,000	13,304	413.8	275,000
Guiana (British)	88,492	2,752.6	1,829,137	77,939	2,424.1	1,611,000
Guiana (Dutch)	18,892	587.6	890,498	21,212	659.8	438,564
Guiana (French)	114,759	3,642.0	2,372,069	101,645	3,161.5	2,101,000
Peru	82,245	2,558.0	1,750,000	63,110	1,963.0	1,304,502
Uruguay	2,796	83.9	57,800	2,796	83.9	57,800
Venezuela	38,704	1,203.8	e 800,000	14,514	451.4	e 300,000
EUROPE:						
Austria	386	12.0	7,977	} 108,635	3,378.9	2,245,500
Hungary	104,841	3,261.0	2,168,023			
Germany (c)	3,025	94.1	62,527	3,416	106.2	70,600
Italy	354	11.0	7,317	1,292	40.2	26,700
Norway	129	4.0	2,658	129	4.0	2,658
Portugal	64	2.0	1,323	64	2.0	1,323
Russia	1,183,379	36,803.8	24,460,044	1,208,530	37,590.5	24,980,320
Spain	457	14.2	9,446	260	8.1	5,382
Sweden	3,022	94.0	62,465	1,640	51.0	33,900
Turkey	997	31.0	20,607	997	31.0	20,607
United Kingdom	4,181	130.0	70,898	3,740	116.3	77,300
AFRICA:						
Transvaal	1,704,410	53,012.7	35,250,155	2,963,681	92,164.3	61,259,281
Abyssinia	33,865	1,053.3	e 700,000	33,865	1,053.3	e 700,000
Rhodesia	172,899	5,377.7	3,573,822	196,682	6,117.7	4,065,436
Soudan	2,701	e 84.0	55,826	2,701	84.0	55,826
West Coast	19,352	601.9	e 400,000	59,981	1,865.6	1,239,807
Madagascar	38,484	1,197.0	795,464	55,150	1,715.4	1,139,963
Mozambique	7,257	225.7	e 150,000	7,257	225.7	e 150,000
ASIA:						
Borneo (British)	32,000	995.3	660,440	35,075	1,090.9	725,000
China	193,517	6,019.0	e 4,000,000	314,417	9,779.4	e 6,500,000
East Indies (Dutch)	41,313	1,285.0	853,940	24,238	753.9	501,000
India (British)	468,495	14,571.7	9,683,798	542,007	16,860.2	11,140,069
Japan	79,570	2,475.0	1,644,757	96,759	3,009.5	e 2,000,000
Korea	169,351	5,266.7	e 3,500,000	169,328	5,266.6	3,500,000
Malay Peninsula	14,961	465.4	309,234	15,724	489.1	325,000
AUSTRALASIA (d)	3,895,903	121,178.9	80,528,316	4,231,362	131,613.1	87,462,252
Unspecified (f)	21,771	677.1	450,000	24,190	752.4	500,000
Totals	14,409,786	448,085.5	$298,412,993	15,803,920	491,553.0	$326,566,926

(a) Figures based on exports and coinage. (b) As reported by the *Statistique de l'Industrie Minerale.* (c) Includes output from domestic ores only. (d) Six States and New Zealand. (e) Estimated. (f) Includes Servia, Persia, West Indies, Formosa, British New Guinea and Philippine Islands. (h) Statistics reported by Mr. George E. Roberts, Director of the United States Mint.

NOTE.—The value of gold is $20.67 per Troy ounce, which is equivalent to $664.60 per kilogram.

Madras, which constitutes the only part of India important in gold mining; the district has achieved importance from this small group of rich mines controlled in London and managed in a conservative manner, so that they are in a condition to maintain a steady production.

The Russian output presents no new features; the yield of that immense territory is important—1,208,530 oz., worth $24,980,320—but it is not subject to violent fluctuation. The center of production is moving steadily eastward, as the old placers of the Ural become exhausted, while the country bordering the Amur river and the region northeast of Lake Baikal becomes developed.

Among the less known gold-producing countries Korea will command interest

SILVER PRODUCTION OF THE WORLD.

Countries.	1902.			1903.		
	Troy Ounces.	Kilograms.	Commercial Value.	Troy Ounces.	Kilograms.	Commercial Value.
AMERICA, NORTH.						
United States	55,500,000	1,726,229.4	$29,415,000	54,300,000	1,688,905.5	$29,322,000
Canada	4,373,000	136,015.0	2,343,450	3,182,000	98,950.2	1,700,779
Mexico (a)	57,982,335	1,803,438.0	30,243,655	67,832,760	2,109,818.0	36,256,610
Central America	1,200,000	37,323.9	625,920	2,100,000	65,316.2	1,122,450
AMERICA, SOUTH:						
Argentina	e 150,000	4,665.4	78,240	e 125,000	3,888.0	66,913
Bolivia	b 7,500,000	233,274.2	3,912,000	e 7,500,000	233,274.2	4,018,750
Chile	b 1,650,000	51,320.3	860,640	e 1,650,000	51,320.3	882,925
Colombia	e 2,520,000	78,380.1	1,314,432	e 2,000,000	62,208.1	1,069,000
Ecuador	e 50,000	1,555.2	26,080	e 40,000	1,244.2	21,380
Peru	4,265,409	132,668.0	2,223,842	e 1,750,000	54,430.6	935,375
EUROPE:						
Austria	1,264,909	39,344.0	659,777	1,279,956	39,812.0	684,136
Hungary	729,002	22,364.0	380,247	729,002	e 22,364.0	389,652
France	751,890	23,387.0	392,187	751,890	e 23,387.0	401,855
Germany (c)	5,735,830	178,408.7	2,911,809	5,830,000	181,020.8	3,110,790
Greece	1,090,367	33,915.0	568,736	1,090,367	e 33,915.0	582,801
Italy	909,363	28,285.0	474,324	909,363	28,285.0	486,055
Norway	206,473	6,422.0	107,697	e 206,473	6,422.0	110,330
Russia	146,898	4,569.0	76,622	260,776	8,111.0	139,347
Spain	6,018,500	190,000.0	3,186,194	4,090,000	127,212.2	2,186,105
Sweden	43,885	1,365.0	22,890	43,885	e 1,365.0	23,457
Turkey	468,297	14,566.0	249,264	468,297	e 14,566.0	250,305
United Kingdom	146,606	4,560.0	76,470	146,606	e 4,560.0	78.361
ASIA:						
Dutch East Indies	124,678	3,878.0	65,032	124,678	e 3,878.0	66,640
Japan	1,770,152	54,745.0	903,311	1,770,152	e 54,745.0	946,146
AUSTRALASIA:	9,724,538	302,464.6	5,072,320	11,909,040	370,110.1	6,365,382
Other countries (d)	48,226	1,500.0	26,155	48,226	1,500.0	25,676
	164,560,358	5,121,469.0	$86,216,294	170,128,471	5,291,545.2	$91,043,221

(a) Statistics compiled from exports and coinage. (b) Statistics furnished by H. R. Wagner. (c) Silver produced from domestic ores only. (d) The output is mostly from China and Persia. (e) Estimated. (f) Estimate furnished by Mr. George A. Roberts, Director of the United States Mint. (g) From the *Statistique de l'Industrie Minerale.*

NOTE.—Unless specified to the contrary, the statistics have been taken from official sources or have been collected directly from the producers by THE MINERAL INDUSTRY. The average commercial value of silver for 1902 was 52.16c. per ounce, equivalent to $16.77 per kilogram. The value for 1903 was 53.45c. per ounce, equivalent to $17.18 per kilogram.

at this time. The output is mainly that of the Oriental Consolidated Mining Company, whose five stamp-mills in 1903 crushed 203,567 tons for a yield of $1,203,165, this work being done by operations the cheapness of which is highly creditable to the management. Total exports of gold from Korea amounted to $3,709,689, most of which went to Japan.

Madagascar exhibits an increase from $799,464 to $1,139,963, chiefly due to the excellence of the French administration.

In the republic of Central America there is notable activity in Nicaragua, Honduras, Salvador and Guatemala. The most important mines are the Rosario in Honduras and the Butters mine in Salvador. A good deal of gold mining on a small scale is being started throughout Central America, and larger returns may be expected as development and equipment make further progress.

In Egypt there was a notable awakening of activity, chiefly as the result of exploratory work done by English companies. In one or two cases a depth of 500 ft. has been attained, ore of a profitable character having been followed. While no startling discoveries have been made, it is reasonable to expect an increasing output as the mills now in course of construction begin crushing.

The world's production of silver in 1903 was 170,128,471 oz. Troy or 5,291,545 kilograms as compared to 164,560,357 oz. or 5,121,469 kilograms in 1902. The increase of about six million ounces is entirely attributable to Mexico, the other countries of the world exhibiting no changes worthy of mention. Mexico has accentuated her leading position with an output of 67,832,760 oz. Troy, valued at $36,256,610 as compared to 57,982,335 oz., valued at $30,243,655 in 1902. The Republic is undergoing energetic development, and there is every reason to expect that the growth in production of both the precious metals will proceed hand in hand; the reopening of old mines, which follows the extension of the railway into districts crippled by heavy freight and smelter costs, is sure to stimulate the production of 1904. In the United States, as stated elsewhere, the output of silver remains nearly steady and is now mainly a by-product in the mining of lead and copper ores.

In Australia there is a slight increase in the yield of silver, despite the severe drought which interrupted operations for several months at Broken Hill, in New South Wales. In Canada the production comes mainly from British Columbia, where a falling off is recorded, from 3,917,917 oz. in 1902 to 2,996,204 oz. in 1903. This decrease is due to the depressing influence of the local market for lead; even the silver contained in dry ores suffers from the lessened output of the lead required for its economical smelting, and until the good effects of the Canadian bounty on lead become apparent, the mining of silver in British Columbia will languish.

On the whole it is becoming more evident each year that the silver production of the world is increasingly a by-product in the winning of the other metals, and this tendency will be further marked in the course of time, unless there is a radical change for the better in the market price of the white metal, as seems in no way likely.

COINAGE OF THE MINTS OF THE UNITED STATES.

Year.	Gold.	Silver.	Minor.	Total.
1899	$111,344,220	$26,061,520	$1,837,452	$139,243,192
1900	99,272,943	36,345,321	2,031,137	137,649,401
1901	101,735,188	30,838,461	2,120,122	134,693,770
1902	47,109,852	30,028,167	2,447,796	79,585,816
1903	43,683,970	19,874,440	2,251,281	65,809,691

The above figures do not include silver, nickel and copper coins struck for the Philippine Islands, Venezuela and Costa Rica.

UNITED STATES: IMPORTS AND EXPORTS OF GOLD AND SILVER.

	1902.		1903.	
	Imports.	Exports.	Imports.	Exports.
Gold:				
Coin and bullion	$22,710,957	$35,722,835	$44,055,430	$43,765,360
In ores	21,482,360	307,756	21,212,266	581,474
Totals	$44,193,317	$36,030,591	$65,267,696	$44,346,834
Silver:				
Coin and bullion	8,502,614	49.228,303	35,041,313	7,935,844
In ores	17,900,321	44,651	5,594,029	16,038,664
Totals	$26,402,935	$49,272,954	$40,635,342	23,974,508

AUSTRIA-HUNGARY: IMPORTS AND EXPORTS OF COIN AND BULLION.

Year.	Gold.		Silver.	
	Imports.	Exports.	Imports.	Exports.
	Crowns.	Crowns.	Crowns.	Crowns.
1899	39,876,000	62,711,000	3,189,000	5,353,000
1900	41,094,000	57,686,000	3,734,000	6,165,000
1901	168,657,000	34,114,000	4,716,000	4,897,000
1902	150,459,000	66,548,000	15,416,000	12,833,000
1903	100,379,000	54,497,920	12,995,750	6,786,290

FRANCE: IMPORTS AND EXPORTS OF COIN AND BULLION.

Year.	Gold.		Silver.	
	Imports.	Exports.	Imports.	Exports.
	Francs.	Francs.	Francs.	Francs.
1900	459,111,000	125,568,000	145,840,000	206,786,000
1901	428,425,000	154,443,000	97,788,000	140,515,000
1902	440,457,000	127,041,000	96,717,000	119,614,000
1903	323,868,000	169,808,664	131,602,000	70,125,336

GERMANY: IMPORTS AND EXPORTS OF COIN AND BULLION.

Year.	Gold.		Silver.	
	Imports.	Exports.	Imports.	Exports.
	Marks.	Marks.	Marks.	Marks.
1899	271,275,000	135,745,000	7,284,000	23,964,000
1900	241,243,000	113,860,000	13,955,000	23,885,000
1901	256,833,000	51,591,000	15,878,000	26,544,000
1902	138,983,000	106,022,000	20,091,000	26,645,000
1903	280,766,000	91,634,000	21,412,000	20,245,000

UNITED KINGDOM: IMPORTS AND EXPORTS OF COIN AND BULLION.

Year.	Gold.		Silver.	
	Imports.	Exports.	Imports.	Exports.
1899	£32,533,497	£21,536,052	£12,727,989	£13,955,132
1900	26,190,873	18,397,459	13,322,300	13,574,580
1901	20,715,628	13,965,265	11,501,678	12,049,837
1902	21,629,049	15,409,088	9,764,296	10,716,118
1903	28,657,393	27,766,512	10,310,330	11,466,726

Production of Gold and Silver in the United States.

By T. A. Rickard.

By the courtesy of the Director of the Mint we are enabled to give the production of precious metals in the United States during 1903, and also the distribution. It will be seen from the tabulated statement that there is a decrease in gold amounting to about $6,500,000, while the silver production shows no appreciable change in value, although there would have been a decrease to record had not the better market price of the metal, which averaged one cent higher, enabled the 54,300,000 ounces produced in 1903 to compare so favorably with the 55,500,000 credited to 1902.

In glancing over the distribution of gold production it will be seen that the diminished yield from Colorado very nearly accounts for the total decrease in the United States as a whole, for the falling off in that State is about $6,000,000. This result is due almost wholly to the labor troubles which have hindered mining in the two leading districts of Cripple Creek and Telluride. California shows a decrease measured by $700,000, though it is probable that an increase would have been recorded if the drought had not shut off water from many of the stamp-mills and placers during the latter part of the year. South Dakota, the next in importance, is without noteworthy change, in spite of a good deal of activity in improved cyanide methods, the benefit of which may become better apparent in 1904. Similarly Montana just about holds her own; the smaller total quantity obtained from Butte ores, in the course of refining the copper product of that region, is balanced by the greater activity which has marked gold mining in the outside districts, especially those of Fergus county. In Arizona there is healthy progress. In Yavapai county, more particularly at Congress and among the mines scattered through the Bradshaw mountains, there has been an increase of activity. There has also been a spurt in the Wickenburg district. Utah exhibits progress, but less than the first estimates seemed to indicate. Idaho has marked time, but Nevada has added $500,000 to her output, although this advance is less than might have been expected, having regard to the developments at Tonopah. However, in that district the mine capable of the largest production has been held down to exploratory work, and several neighboring young mines are still in course of equipment and development, so that 1904 will be more likely to reflect the successful operations of the past year than the record of 1903 itself.

The southern States show a falling off, but their total output has never been commensurate with the efforts made to stimulate the interest in them.

Alaska has not done as well as in 1902, although many who were aware of the general activity throughout the far North expected a better showing. The output from the sands at Nome has been decreasing, and this decrease has more than balanced the better yield from the new regions now in process of being opened up. Nome produced $5,050,000 in 1902, while in 1903 the total was only $4,476,775. The present year brings the promise of a further expansion of lode mining throughout southeastern Alaska, more especially in the Juneau district.

In silver production Colorado still holds the lead which it won from Nevada nearly twenty-five years ago. It was the yield from the Leadville ore-bodies which enabled Colorado to win the supremacy in 1880, at a time when the Comstock mines were beginning to decline. Since then Leadville has continued to be the most important contributor; and although its output attained a maximum in 1887, the production of ore is still large in amount. It is no longer the high-grade silver-lead product of the early days, but principally iron ore, containing a little silver and valuable for fluxing purposes. During 1903 a large tonnage, amounting to 50,000 tons per month, was made, the bulk of it being destined to make a suitable smelting mixture with silicious ores from other districts; for it is the availability of such mixtures that has built up great smelting centers at Denver and Pueblo.

In the silver production of Utah the great mines at Park City continue to exhibit remarkable vitality, and are responsible for an increased output. Bingham and Tintic have also contributed through the silver separated by refining from their large output of copper bars and matte.

Montana shows a slight falling off, due largely to interruption in mining at Butte by reason of vexatious litigation, harrassing to the copper mines, the output of which includes an important contribution of silver. There has been greater activity among the lessees in the Walkerville mines, but the old Phillipsburg district, once a prolific producer, is now unimportant, and no new silver resources have been opened up elsewhere in the State. Idaho has done better than last year, by reason of the increased activity in the Cœur d'Alene region, now no longer crippled by labor troubles. Nevada put out about $500,000 more in silver, this being due to Tonopah. As the new camp gets into stride there ought to be a further growth in Nevada's output, for it is a fact that the State once made so famous by the Comstock and Eureka has taken on renewed vigor during the last two years. Arizona a little more than holds her own, but when the Tombstone mines are unwatered and fully reopened there will be a notable increase. The water-level at the close of 1903 was 100 ft. below the 600-ft. station of the old Contention mine, and there is a probability of some return to the productiveness which made Tombstone famous about twenty years ago.

On the whole the statistics for 1903 indicate that there is no important change in the mining of the precious metals in the United States, for the silver output remains practically the same, and that of gold shows a decrease due entirely to labor troubles in Colorado, creating an obstacle to mining which is only temporary. The outlook for 1904 includes many promising features. Of these a betterment of labor conditions in Colorado is reasonably to be expected; Utah is undoubtedly undergoing notable development, especially in the production of gold and silver-bearing copper bullion; in Nevada the exploitation of the new districts is likely to exhibit statistical results, while in California and South Dakota normal progress will serve to maintain the present output, even if it is not increased.

PRODUCTION OF GOLD IN THE UNITED STATES. (a)

	1900.		1901.		1902.		1903.	
	Fine Ounces.	Value.	Fine Ounces.	Value.	Fine Ounces.	Value.	Fine Ounces.	Value.
Alabama . .	92	$1,900	150	$3,100	119	$2,500	213	$4,400
Alaska	395,271	8,171,000	333,096	6,885,700	403,730	8,345,800	416,738	8,614,700
Arizona . . .	202,856	4,193,400	197,515	4,083,000	198,933	4,112,300	210,799	4,357,600
California. .	765,109	15,816,200	817,121	16,891,400	812,319	16,792,100	779,057	16,104,500
Colorado . . .	1,394,622	28,829,400	1,339,673	27,693,500	1,377,175	28,468,700	1,090,376	22,540,100
Georgia. . . .	5,644	116,700	6,023	124,500	4,730	97,800	3,000	62,000
Idaho	83,433	1,724,700	90,427	1,869,300	71,352	1,475,000	75,969	1,570,400
Maryland. .	5	100	....	....	121	2,500	24	500
Michigan . .	1,403	29,000	1,490	30,800	....	....	....	....
Montana. . .	272,266	4,698,000	229,495	4,744,100	211,571	4,373,600	213,425	4,411,900
Nevada. . . .	97,050	2,006,200	143,374	2,963,800	140,059	2,895,300	163,892	3,388,000
New Mexico	40,292	832,900	33,302	688,400	25,693	531,100	11,833	244,600
N. Carolina.	1,379	28,500	2,685	55,500	4,390	90,700	3,411	70,500
Oregon	81,880	1,694,700	87,950	1,818,800	87,881	1,816,700	62,411	1,290,200
S. Carolina.	5,854	121,000	2,259	46,700	5,896	121,900	4,872	100,700
S.Dakota. .	298,842	6,177,600	313,446	6,479,500	336,952	6,265,400	330,243	6,826,700
Tennessee. .	5	100	....	....	....	....	38	800
Utah.	192,155	3,972,200	178,513	3,690,200	173,886	3,594,500	178,863	3,697,400
Virginia . . .	155	3,200	256	5,300	148	3,100	654	13,500
Washington	34,743	718,200	28,082	580,500	13,166	272,200	13,589	279,900
Wyoming. .	1,655	34,200	614	12,700	1,879	38,800	175	3,600
Other States	86	1,800	29	600	....	....	468	9,700
	3,829,897	$79,171,000	3,805,500	$78,666,700	3,870,000	$80,000,000	3,560,000	$73,591,700

(a) Statistics furnished by Mr. George E. Roberts, Director of the United States Mint.

Progress of Gold and Silver Mining During 1903.

Alaska.—The year's activity in the various gold districts of Alaska is reviewed by Alfred H. Brooks elsewhere in this volume. The following notes covering the operations of the large quartz mines on Douglas Island are supplementary to the review of Mr. Brooks.

The Alaska Treadwell Gold Mining Company mined and treated 756,325 tons of ore during the year ending May 30, 1903, producing bullion to the value of $1,598,963. The company owns two stamp-mills with a total of 540 heads. In the old mill of 240 stamps the ore crushed was 409,765 tons, an average of 4.8 tons per stamp per day; the total crushed in the new mill of 300 stamps was 346,560 tons, or an average of 5.75 tons per stamp per day. Owing to shortage of water the new mill was run only 200 days during the year. From the gross income of $1,665,702 the net earnings amounted to $692,209, after deducting $922,080 ($1.219 per ton) for working expenses, $17,033 ($0.0226 per ton) for office and incidental expenses, and $34,380 ($0.0454 per ton) for new construction. To the net profit for the year is to be added $813,898 brought forward from 1902, and $43 from expense account, making a total of $1,506,150. From this total four dividends amounting to $375,000 in all were paid on the capital stock of $5,000,000, and the sum of $448,493 was written off for depreciation of property and plant, leaving a balance of $682,657 to be brought forward. The ore reserves at the close of the year were estimated at 4,287,138 tons.

PRODUCTION OF SILVER IN THE UNITED STATES. (a)

	1900.		1901.		1902.		1903.	
	Fine Ounces.	Commercial Value.	Fine Ounces.	Commercial Value.	Fine Ounces.	Commercial Value.	Fine Ounces.	Commercial Value.
Alabama . .	100	$62	100	$60	100	$53	....	....
Alaska	73,300	45,446	47,900	28,740	92,000	48,760	143,600	$77,544
Arizona . . .	2,995,500	1,857,210	2,812,400	1,687,440	3,043,100	1,612,843	3,387,100	1,829,034
California. .	941,400	583,668	925,600	555,360	900,800	477,424	931,500	503,010
Colorado. . .	20,483,900	12,700,018	18,437,800	11,062,680	15,676,000	8,308,280	12,990,200	7,014,708
Georgia. . . .	400	248	400	240	400	212	400	216
Idaho	6,429,100	3,986,042	5,542,900	3,325,740	5,854,800	3,103,044	6,507,400	3,513,996
Michigan . .	102,000	63,240	81,000	48,600	110,800	58,724	50,000	27,000
Montana. . .	14,195,400	8,801,148	13,131,700	7,879,020	13,243,800	7,019,214	12,642,300	6,826,842
Nevada. . . .	1,358,700	842,394	1,812,500	1,087,500	3,746,200	1,985,486	5,050,500	2,727,270
New Mexico	434,300	269,266	563,400	338,040	457,200	242,316	180,700	97,578
N. Carolina.	11,200	6,944	20,300	12,180	20,900	11,077	11,000	5,940
Oregon	115,400	71,548	160,100	96,060	93,300	49,449	118,000	63,720
S. Carolina .	400	248	200	120	300	159	300	162
S. Dakota. .	536,200	332,444	78,000	46.800	340,200	180,306	221,200	119,448
Tennessee. .	....	....	....	....	12,300	6,519	13,000	7,020
Texas	477,400	295,988	472,400	283,440	446,200	236,486	454,400	245,376
Utah.	9,267,600	5,745,912	10,760,800	6,456,480	10,831,700	5,740,801	11,196,800	6,046,272
Virginia . . .	....	....	700	420	5,900	3,127	9,500	5,130
Washington	224,500	139,190	344,400	206,640	619,000	328,070	294,500	159,030
Wyoming. .	200	124	21,400	12,840	5,000	2,650	200	108
Other States	....	....	....	....	....	....	97,400	52,596
	57,647,000	$35,741,140	55,214,000	$33,128,400	55,500,000	$29,415,000	54,300,000	$29,322,000

(a) Statistics furnished by Mr. George E. Roberts, Director of the United States Mint.

The Alaska Mexican Gold Mining Company, during the year 1903, treated 239,453 tons of ore in its mill of 120 stamps, or an average of 5.59 tons per stamp per day. The total receipts from bullion recovered in the mill and from sulphurets was $699,383, while the costs amounted to $441,751. Out of the net profits of $257,634 two dividends aggregating $108,000, or 12 per cent on the capital stock, were paid, and the sum of $59,521 written off for depreciation, leaving a balance of $90,113. The total surplus on hand at the close of the year was $212,644.

The Alaska United Gold Mining Company operates the Ready Bullion mine, and leases a second mine known as the 700-ft. claim to the Alaska Treadwell Company. During the year 1903 it treated 202,881 tons of ore or 4.78 tons per stamp per day. The gold recovery was $329,458, while the expenses for mining, milling and construction amounted to $338,544, showing a deficit of $9,086 for the year's operations.

Arizona.—The production of gold in 1903 showed a fair increase over that of the preceding year. There was considerable activity in the development of gold properties, particularly in the Bradshaw Mountain district, and some promising mines are being opened. One of the largest of the new mines is the Poland, which should become a producer during the current year. The Congress mine was operated steadily although not at full capacity, the old mill of 40 stamps being idle part of the year. The Tombstone mines have begun shipments of silver-gold ores to El Paso, and a steady increase in the output of these mines may be expected for some time. A more detailed review of the year's progress in mining by William P. Blake will be found on a subsequent page in this volume.

California.—There was little change in the gold-mining industry during the year, and the output was approximately the same as in 1902. The drought during the latter part of the year affected many of the quartz mines and placers, curtailing the production quite extensively. The dredging industry showed the most activity. At Oroville, in Butte county, 27 dredges have been placed in operation, and several more are working in other districts. The yield of gold from this source more than doubled during the year. For further details relative to gold mining in 1903 reference should be made to the review by Charles G. Yale elsewhere in this volume.

Colorado.—A review of the year's developments in the mining industry of Colorado by Forbes Rickard will be found on a subsequent page in this volume.

There was a large decrease in the production of gold, the output for 1903 being approximately $6,000,000 less than in the previous year. The unfavorable result was due largely to the labor troubles which hindered mining in the two leading districts of Cripple Creek and Telluride. The production of silver also showed a falling off and was exceeded by that of Utah. Colorado has held the lead as the greatest silver-producing State since 1880, and its drop to second place is associated with the decline of the Leadville district. The following statistics, compiled by E. L. White, Commissioner of Mines, show the distribution of the gold and silver production in 1903.

County.	Gold.		Silver.		County.	Gold.		Silver.	
	Ounces.	Value.	Ounces.	Value.		Ounces.	Value.	Ounces.	Value.
Boulder.	20,879	$431,569	61,833	$33,050	San Juan. .	82,758	$1,710,608	781,358	$417,636
Clear C'k	22,838	472,061	851,683	455,225	San Miguel	56,933	1,176,805	737,028	393,941
Gilpin . .	65,124	1,346,113	375,238	200,565	Summit. . .	10,753	222,265	220,543	117,880
Lake . . .	64,827	1,339,974	4,973,033	2,658,086	Teller.	572,824	11,840,272	41,605	22,238
Mineral .	8,658	178,961	1,608,788	859,897	Miscella's .	34,372	710,469	607,169	324,532
Ouray . .	105,056	2,171,508	417,343	223,070					
Pitkin . .	230	4,754	2,569,862	1,373,591	Total. . .	1,045,252	$21,605,359	13,245,483	$7,079,711

Idaho.—According to the report of Robert N. Bell, Inspector of Mines, the production of gold in 1903 was 92,938 oz., valued at $2,085,994. The following counties contributed over $200,000 each to the total: Owyhee, $493,955;

Boise, $318,080; Idaho, $301,649; and Lemhi county, $235,426. The silver output, according to the same authority, amounted to 7,224,022 oz., valued at $3,921,086. Shoshone county, in which the Cœur d'Alene district is situated, produced nearly 80 per cent of the silver mined in the State. In Owyhee county the Trade Dollar and De Lamar mines increased their output of gold and silver. The Trade Dollar Consolidated Company now operates also the Black Jack and Booneville mines, which are on the same vein and are connected by adits. Boise county, with the famous placer district of Boise basin, was the second largest producer of gold. Most of the output was derived from the hydraulic mines near Idaho City, the dredging plants at Idaho City and Centerville and the steam shovel plant on Granite creek. Quartz mining is on the increase, although still in its infancy. The Gold Hill mine, which was recently shut down after years of successful operation, is to be equipped with modern machinery and will be actively worked. In Idaho county the Buffalo Hump district is undergoing solid development. At the Jumbo mine a new 30-stamp mill has been erected, together with air-compressor, electric light and water-power plant. The Cracker Jack mill contains 10 stamps and will be driven by electric power. When the two mills are in running order their output should exceed the present production of Idaho county. In the Thunder Mountain district the Dewey mine operated its 10-stamp mill, and development work was done on the Sunnyside, Fairview, East Dewey and H. Y. claims. The development of this district has been seriously retarded by its remoteness and the excessive cost of supplies, but this difficulty will be partially removed by the construction of the wagon road from Long valley, Boise county.

Blaine county has a large number of active mines, the gold belt beginning about 12 miles west of Hailey, and continuing to the northwest corner of the county. Tip Top mine has a shaft run 900 ft. down a steep incline, with a 200-ft. winze below. The ore found in this winze averages nearly an ounce of gold per ton. The Crœsus mine has a three-compartment shaft down 500 ft. In Custer county the Lucky Boy vein has shown a marked increase in values, especially gold, indicating that similar improvements may take place in other mines in the locality as depth is reached.

Nevada.—A notable increase in both gold and silver was recorded in this State during 1903. The growth, however, was less than it would have been had the Tonopah district made the output that was expected. The largest mine in that district was held down to exploratory work, and several neighboring mines were still in course of equipment and development, so that 1904 will be more likely to reflect the successful operations of the year than 1903 itself. The Tonopah Mining Company, in its report for the year ending February 29, 1904, states that its receipts were $615,475, of which $598,224 was derived from the sales of ore. The company owns eight mineral claims in the district, including the discovery locations, and has a capital stock of $1,300,000. The net profits were $27,955, to which the sum of $187,329 brought forward from the previous year is to be added, making a total of $215,284 on hand at the close of the year. The quantity of ore raised was 15,294 tons, of which 4,066 tons were shipped to the smelter. For further information relative to gold and silver mining in Nevada reference may be made to the review by J. E. Spurr included in this volume.

Southern States.—The progress of mining in the Southern States in 1903 is reviewed by Richard Eames, Jr., on a subsequent page in this volume.

South Dakota.—The production of gold continued at about the same rate as in 1902. The Homestake Mining Company, during the year ending June 1, 1903, treated 1,279,075 tons of ore which yielded bullion valued at $4,526,942 or $3.54 per ton. The total income was $4,629,721, and the expenses $4,026,099 or $3.15 per ton, leaving net earnings of $603,622 or $0.47 per ton. After paying dividends of $819,000 there was a deficit at the close of the year of $425,785. An additional 100 stamps is to be added to the mill. A review of mining in South Dakota during 1903 by Samuel S. Arentz will be found elsewhere in this volume.

New Mexico.—A discovery of placer gold in the southern part of the Sierra de los Caballos was the most important event of the year in the mining of precious metals. Owing to the richness of the discovery locations the district received unusual attention from prospectors, and all available ground was soon taken up. According to Charles R. Keyes[1] the placers are about 20 miles north of Rincon, extending along Apache cañon for a distance of 10 miles on each side. The gold occurs in coarse particles and can be separated by an ordinary fan, which is being employed with success. There is abundance of water for mining purposes.

Utah.—A notable advance was made in the output of both gold and silver, the aggregate increase for the two metals being approximately $4,000,000. The larger gold production was due in part to the expansion of mining operations in the Bingham district, where a rapidly growing copper industry has brought about a proportionate increase in the output of precious metals that accompany the copper ores. The Tintic district also contributed to the advance, which would have been more marked if Mercur had not dwindled in importance. As regards the silver production of Utah, the great mines of Park City continued to exhibit remarkable vitality, and were responsible for the larger output.

The United States Mining Company maintained its smelting plant of four furnaces in steady operation and produced about 8,000,000 lb. of high-grade copper bullion. The Utah Consolidated Company, also in the Bingham district, turned out 13,250,000 lb. of bullion, and will increase its output during the current year. A new copper smelter near Bingham is under construction by the Tintic Mining & Development Company, which will handle the ore from the Yampa mine owned by the company. The Park City district, which

1 The Engineering and Mining Journal, Dec. 24, 1903.

includes the Daly-West, Ontario, Daly and Silver King mines, experienced a prosperous year. The Daly-West Mining Company reported an output of 62,346 tons of first-class shipping ore and 76,240 tons of concentrating ore, from the sales of which the sum of $2,382,258 was realized. The ore sold contained 3,195 oz. gold, 4,382,222 oz. silver, 3,160,824 lb. copper and 34,742,791 lb. lead. The total expenses for the year were $856,751, and the net profits $1,531,480. Dividends aggregating $1,332,000 were paid, and there was a surplus on hand of $454,996. The Horn Silver Mining Company, near Frisco, mined 17,348 tons of ore in 1903, containing 836 oz. gold, 96,027 oz. silver, 434,409 lb. copper and 5,505,694 lb. lead. The total receipts were $138,478, from which the net earnings amounted to $4,515.

Washington.—The shipments of ore from the Republic district in 1903 amounted to about 50,000 tons, but the output was restricted by inadequate smelting facilities. The Granby, Northport and Everett smelters handle most of the shipping ore. The Republic Consolidated Gold Mining Company was forced into receivership by the exhaustion of the ore-bodies, and it is not believed that operations will be resumed. The large mill owned by the Republic Power & Cyaniding Company also suspended operations. The Mountain Lion mine overhauled its 20-stamp mill to adapt it to the Hendryx cyanide process. The Everett smelter was sold to the American Smelting & Refining Company which closed it down early in 1904. The Great Excelsior mine at Mt. Baker erected a 40-stamp mill, and the Mammoth mine in the same district increased the capacity of its mill. The Turk Mining Company in Cedar Cañon has installed a mill costing $75,000. The Musick Mining Company at Sumas mountain has begun the construction of a cyanide plant of 200 tons daily capacity.

Progress of Mining in Foreign Countries.

Australia.—The production of gold in Australia, including Tasmania and New Zealand, is shown in the following table. The output for 1903 was the largest ever recorded, the increase over the previous year being nearly 10 per cent.

PRODUCTION OF GOLD IN AUSTRALASIA.

States.	1901.		1901.		1903.	
	Fine Oz.	Value.	Fine Oz.	Value.	Fine Oz.	Value.
New South Wales	216,888	$4,483,075	161,255	$3,333,146	254,260	$5,255,554
New Zealand	412,875	8,534,126	458,933	9,486,145	479,746	9,916,350
Queensland	598,382	12,368,556	640,463	13,238,370	668,546	13,818,846
South Australia (*a*)	21,946	453,624	24,082	497,775	22,269	460,300
Tasmania	69,491	1,436,789	70,996	1,467,487	59,891	1,237,947
Victoria	730,449	15,098,380	720,866	14,900,300	767,351	15,861,145
Western Australia	1,669,072	34,799,718	1,819,308	37,605,096	1,979,299	40,912,110
Totals	3,719,103	$77,174,268	3,895,903	$80,528,316	4,231,362	$87,462,252

(*a*) Includes Northern Territory.

For details as to the progress of the industry in the five States of Australia the reader is referred to the reviews by A. G. Charleton and F. Danvers Power elsewhere in this volume.

New Zealand.—The production of gold in 1903, as indicated by the exports, amounted to 533,314 oz. crude, valued at £2,037,831, which is equivalent to 479,746 oz. fine, or a value of $9,916,350. The output was the largest since 1871 and shows an increase over the previous year of about $450,000. Much of the gain has been due to the development of quartz mining in the Ohinemuri district, where there are several successful enterprises, including the Waihi Gold Mining Company, one of the largest producers of gold in the world. During the year ending September 30, 1903, the mine produced 231,323 tons of ore, which yielded gold to the value of £658,393, or approximately £2 16s. per ton. The mill is equipped with 330 heads of stamps. During the year the company made many improvements, with the view of working the mine to increased depth. A new pumping plant was installed and the hoisting facilities increased to 1,000 tons per day. The Consolidated Gold Fields of New Zealand, including the Progress, Golden Fleece and Wealth of Nations mines, did not quite maintain the 1902 record. At the Progress in 1903 57,114 tons of ore were crushed, the gold recovered being £108,219, and the profits £63,421; at the Golden Fleece in 1903 14,133 tons of ore were crushed, the gold value was £26,469, and the profits £9,234; and at the Wealth of Nations 12,385 tons of ore were crushed, the gold value was £20,059, and the profits £9,773.

There were no new developments of importance in the gold dredging industry. The output in Otago and Southland, where this form of mining is carried on most extensively, fell off owing to abnormal fluctuations of the water level in the rivers and to the severe winter. On the West coast, however, the conditions were more satisfactory, and some progress was made. The production of gold by dredging operations was as follows: Otago and Southland, 87,130 oz.; West coast, 30,619 oz.; total, 117,749 oz.

The output of silver in New Zealand in 1903 was 911,914 oz., valued at £91,497, as compared with 673,986 oz., valued at £72,001, in 1902.

Brazil.—The State of Minas Geraes produces the greater part of gold accredited to Brazil; alluvial deposits in other parts of the country, particularly on the border of French Guiana, yield the remainder of the output. The most prominent mines in Minas Geraes are the Morro Velho (St. John del Rey), Passagem, (Ouro Preto) Vieira and Santa Guiteria, all situated within the limits of a small district.

The Morro Velho mine, operated by the St. John del Rey Mining Company, produced 68,562 oz. fine gold during the year ending February 29, 1904. The quantity of ore raised was 156,158 tons, of which 145,481 tons were treated. The bullion returns amounted to £297,496, an average of $9.60 per ton of ore treated. Dividends of 1s. per share were paid from the net earnings of £59,370. The company has issued 10 per cent preference shares to the extent of £100,000 in order to instal an electric power plant. The Ouro Preto Gold Mining Company, during the year ending June 30, 1903, produced 23,808 oz. gold and paid a dividend of 10 per cent.

Canada.—The production of gold in 1903, according to the official statistics compiled by Elfric Drew Ingall, was valued at $18,834,490, equivalent to 911,199 oz. fine. This shows a decrease of about $2,500,000 from the output of 1902, for which the smaller yield of the Klondike placers was chiefly responsible.

British Columbia.—There was little change in the gold-mining industry during 1903, and in fact for the past three years the output has been nearly stationary. A total of 285,825 oz., valued at $5,873,036, was recovered in 1903, against 290,148 oz., valued at $5,962,409 in the previous year. The Trail Creek mines in the Rossland division continued to be the largest producers, yielding 145,353 oz., valued at $3,004,446, or more than one-half of the total for the Province. The silver production was the smallest for many years, amounting to 2,996,204 oz., valued at $1,521,472, against 3,917,917 oz., valued at $1,941,328 in 1902. A large portion of the silver is derived from silver-lead ores, and the output has been influenced adversely by the depressed market for lead. A general review of the mining industry in British Columbia during 1903 will be found on a subsequent page of this volume.

OUTPUT OF TRAIL CREEK MINES FROM 1899 TO 1903.

Year.	Tons of Ore.	Gold. Oz.	Value.	Silver. Oz.	Value.	Copper. Lb.	Value.	Total Value.
1899 . .	172,665	102,976	$2,127,482	185,818	$105,173	5,693,889	$996,431	$3,229,086
1900 . .	257,636	111,625	2,306,172	167,378	97,648	2,071,865	335,435	2,739,300
1901 . .	283,360	132,333	2,735,323	970,460	543,458	8,333,446	1,342,518	4,621,299
1902 . .	329,534	162,146	3,351,558	373,101	184,871	11,667 805	1,356,966	4,893,395
1903 . .	360,186	145,353	3,004,446	209,537	106,403	8,652,127	1,145,109	4,255,958

Dawson.—According to official authorities the production of gold in the Yukon territory during 1903 amounted to $12,500,000, a decrease of $2,000,000 from the output of the previous year. The statistics are based on records furnished the United States Mint at San Francisco and other receiving offices, and are necessarily only an approximation. A certain amount of the gold produced each year is carried out of the territory by individuals without being recorded, while a further portion is retained in the country for monetary purposes. The Canadian Government exacts a royalty of 2.5 per cent on gold exported from the territory.

The decline in the mining industry during the past three years has been due to the exhaustion of the richer placers in the vicinity of Dawson, without commensurate new discoveries. There is still, however, a large area of ground that can be profitably worked, and it is probable that the production can be maintained at the present rate for some time to come. The policy of the Government in devoting a part of the royalty received from exports to the construction of wagon roads is having a beneficial influence on the industry. Several hundred miles of good roads have been completed throughout the Klondike, which have made it possible to work placer-ground that under former conditions could not be treated at a profit. The usual limit of pay gravel at present, according to R. A. F. Penrose, is about $9 per cubic yard, while the ordinary average runs from $30 to $50. With improvements in the conditions of transportation and labor, material carrying smaller values will be worked in the future, but the short summers and frozen ground will always operate against the reduction of costs to a level permitting the very low-grade ground to be mined.

Some new discoveries were made during the year. The Alsek district, 150 miles west of Whitehorse, was the scene of considerable activity, but sufficient development has not been done as yet to disclose the extent of the deposits. The workings are situated on Bullion and Ruby Creeks, Lake Dezadeash. From one hole in Bullion Creek 42 oz. were taken, and it is reported that a good yield was obtained by the miners who operated in the district during the winter. Rich ground has been found on Duncan Creek, although, owing to the depth of the gravel, no systematic effort at mining can be made until the introduction of suitable machinery. A road is to be built to the camp during the present season.

Auriferous quartz veins have been found on the Violet Hill group of claims near Eldorado Creek. The Government has promised to assist in developing the deposits, with the hope of establishing quartz mining on a successful basis.

The present methods of mining in the Klondike are described in an interesting manner by R. A. F. Penrose.[2] The placers in the Klondike as elsewhere are usually the richest on bed rock. When the overburden of barren ground is not too thick, it is removed before mining the rich gravel below, but usually this overburden is too great, and then underground mining is carried on. This is generally done by sinking shafts to the bottom of the gravel, driving along the bed rock, and removing the rich material which is hoisted to the surface to be washed. As the gravel a short distance below the surface is frozen both summer and winter, it has to be thawed before it is removed. Thawing was formerly done by building fires against the frozen ground, and this practice still prevails in some places; but in the larger operations thawing is done by steam injected through iron pipes previously driven into the frozen gravel, or by a spray of water allowed to play against the frozen ground. In many places underground mining is carried on during the winter as well as in summer, the gravel mined during the winter being piled on the surface until it can be washed in the summer. Washing is done with sluices of lengths varying according to the different character of the gold; but as the gold is mostly coarse, the sluices are usually short. Steam hoists are often used to raise the gravel to the sluice heads, as in some cases steam shovels are being introduced to dig the gravel in the open cuts. On Bonanza Creek a steam dredge is in use.

Hydraulic mining has been carried on in a few places with success, but in many instances it has failed on account of lack of water. This difficulty is especially marked in the case of the bench gravels, which occupy higher elevations than the creek gravels. In some places a limited amount of water is

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[2] The Engineering and Mining Journal, Nov. 28, 1903.

pumped up to the higher elevations and used for hydraulicking or sluicing, but it is an expensive method and can only be employed where the gravel is very rich. The water question is a very serious problem, and is undoubtedly the cause of a much smaller production than could otherwise be made.

Nova Scotia.—There was a slight decrease in the production of gold, the total for the year ending September 30, 1903, being 25,198 oz., valued at $478,762, against 28,279 oz., valued at $537,302 for the corresponding period of the previous year. The goldfields extend from Canso to Yarmouth, and cover an area of 3,000 square miles. A new impetus has been given to the mining industry by the results of the recent geological survey, which indicate that the lodes may continue to much greater depths than have been attained in any of the present workings. It appears that the lodes are found at the crests of anticlinal folds, resembling saddle reefs, and, therefore, may be expected to recur in vertical succession along the planes of the folds. At the Doliver mountain, Richardson, Bluenose and Dufferin mines shafts are being carried down with a view of intersecting the deeper lodes. By the close of the year the Bluenose shaft had been sunk to a depth of 410 ft. with favorable results. The Provincial Government has offered to assist in putting down three shafts to a depth of 2,000 ft. for the purpose of testing the deeper saddle veins.

Ontario.—The production of gold by the mines of Ontario in 1903 was 10,383 oz., valued at $188,036. The falling off from the output of the previous year was due to the temporary suspension of operations at Deloro. The progress in the mining industry in the province during 1903 is reviewed by Thomas W. Gibson elsewhere in this volume.

Colombia.—Gold mining has been stimulated in the past year by the introduction of foreign capital, and many new enterprises have been started. One of the largest mines in the country is the Zancudo, situated near Titiribe, which is credited with a total output of $10,000,000. Near by the Otromina has 18 stamps in operation on ore averaging $20 per ton. The Frontino & Bolivia Mining Company owns properties in the vicinity of Remedios, where it is installing a 500-h.p. electric plant. The El Cerro mines have been operated by an English company which intends to erect a large reduction plant. The discovery of a rich lode near Andes was reported during the year.

Costa Rica.—The exports of gold in 1902 were valued at $247,410. There are two groups of mines in the country, the Bella Vista, which includes the Bella Vista and Thayer mines, and the Abengarez group, including the Tres Amigos, Tres Hermanos and Boston mines. The Bella Vista group is situated near Miramar, 15 miles from Punta Arenas, while the Abengarez field is 18 miles from Puerto Yglesias on the gulf of Nicoya.

Ecuador.—The gold-mining industry has attained, so far, only small proportions, although placer and lode deposits are known to be quite widely distributed. Besides the numerous gold-washing enterprises of the Indians, an American company has installed a hydraulic plant at Esmeraldas and is working gravels that yield about 14c. per cubic yard. The principal quartz mines are situated in the Zaruma district, province of El Oro; since 1897 they have been under operation by the South American Development Company. According to J. W. Mercer[3] the deposits consist of quartz veins intersecting andesite and carrying 10 or 12 per cent sulphides in the form of galena, blende, pyrite and chalcopyrite. The gold occurs both free and in the sulphides. The treatment consists of amalgamation followed by cyanidation. The mill has 40 stamps of 850 lb. each and is driven by water power. About 35 per cent of the gold is recovered on the plates, the bullion assaying 650 to 670 fine. The milling costs are about 50c. per ton. All the tailings from the mill are sent to the cyanide plant without concentrating or sizing. The plant comprises four rubber dams with distributors and slime gates; eight 50 by 30-ft. steel vats; 11 sets of zinc boxes; storage tanks, pumps, etc. The extraction averages 65 per cent, and costs about $1.25 per ton.

Egypt.—A great deal of interest has been shown in the development of gold mining in Egypt and the Soudan, following the exploratory work done by the various companies who have received governmental concessions. No less than 26 new companies were registered during the year. On the property of the Um Rus Gold Mines of Egypt two shafts have been sunk to a depth of about 500 ft. along a reef that carries from 8 dwt. to 1 oz. gold per ton. About 5,000 tons of ore have been opened up, and the company will erect a stamp mill during the present year. The mine is to be connected with the port of Quebarak by a railway. The Nile Valley Company is working on its Um Gariat concession and will erect a 10-stamp mill. On the property of the North Nile Valley Company at Haimur a small output of gold was made from exploratory operations. The lode averages 30 in. wide and carries values up to 1.05 oz. per ton. The Egypt & Soudan Mining Syndicate is sinking five shafts on the Hamesh and Samut properties, following a reef that ranges from a few inches to 5 ft. in width. This company has obtained concessions covering an area of 22,000 sq. miles and has made 33 mining locations. Exploratory work is also being done at Eridia, Attala, Hegath Mount, Um Teor, Globait and Dareheib.

Gold Coast and West Coast.—There was a good deal of activity in gold mining during 1903, although the progress of the industry has been less rapid than expected, owing to the unfavorable climatic conditions and lack of transport facilities. A new feature for this region has been the introduction of gold dredging. The Ashanti Goldfields Auxiliary, Ltd., had one dredge in operation during the past year, which gave such good results that two additional dredges will be erected. The Bibiani Goldfields, Ltd., which owns a concession 70 miles from Dunka, has planned to erect a 40-stamp mill and cyanide plant. The Tremain mills operated by this company crushed 15,144 tons of ore, up to March 1, 1904, producing 8,916 oz. fine gold. The Ashanti Goldfields Corporation, Ltd., has erected a 50-stamp mill and a cyanide plant

3 THE ENGINEERING AND MINING JOURNAL, Aug. 15, 1903.

at Obuassi. Among the properties of this company are the Ayeinm mine, which during the year ending June 30, 1903, produced 6,280 oz. from 10,707 tons of ore; the Côte d'Or mine, which produced 6,357 oz. from 9,698 tons, and the Obuassi mine, which yielded 10,363 oz. from 3,913 tons of ore. The Wassau company began crushing at its Adjak Bippo mine early in 1904. At the Cinnamon Bippo property about 500 natives have been employed in development work.

Guatemala.—The mining of gold is limited to a small district in the foothills of the mountain range dividing Guatemala and Honduras. The principal mines are those of Las Quebradas, situated 15 miles from Morales, which have been worked for the past 25 years by hydraulicking. The yield is said to vary from 20c. at the surface to $9 per cubic yard for the richest gravel along bed rock.

Guiana.—The exports of bullion from British Guiana in 1903 amounted to 86,480 oz. against 102,186 oz. in 1902. The bullion exported in 1903 was equivalent to 72,877 oz. fine or $1,506,356.

The production of gold in French Guiana in 1902 was reported officially as 3,642 kg. fine, equivalent to $2,672,049. There was unusual activity in placer mining during 1903, and the output as indicated by exports showed an increase over the previous year. New discoveries were reported along the upper reaches of the Mana river, a journey of some 30 or 40 days from the coast.

The production of gold in Dutch Guiana in 1903 by districts was as follows, the amounts being stated in kilograms: Surinam, 243; Saramacca, 149; Marowine, 37; Lawa, 230; total 659 kg. as compared with 588 kg. in 1902. The output in 1903 was equivalent in value to $437,971.

Honduras.—The largest mining enterprise in the republic is the New York & Honduras Rosario Mining Company at San Juancito in the department of Tegucigalpa. The mines are worked for both gold and silver; the silver exists as sulphide, while the gold is native and finely divided. During the year ending November 30, 1903, the quantity of ore mined was 15,620 tons, from which 3,653 oz. gold and 683,806 oz. silver were recovered. Measures have been taken to improve the transportation facilities and to reduce the cost of ore treatment. The Aramecina Gold & Silver Mining Company operates a mine in the Lepaterique mountains, 30 miles from the gulf of Fonseca. The output has been as high as 30,000 oz. gold in a year, but lately it has fallen off. In the department of Alancho both lode and placer deposits are found. The principal lode mines are El Corazal, San Francisco, Monte, Jano Concordia and Rosario; the largest placers are on a tributary of the Rucio river, but there are many other streams that contain workable deposits.

India.—The yield of the Kolar field in 1903 amounted to 597,786 oz. crude, valued at £2,287,000, as compared with 513,220 oz., valued at £1,959,268 in the previous year. This is the largest output recorded in the history of the field. There were seven companies engaged in productive operations, or one more than in 1902, the leading mines being the Mysore, Champion Reef, Ooregum and Nundydroog. Of the total reported about two-thirds was contributed by the Champion Reef and Mysore companies. The former company produced 211,513 oz. in 1903, as compared with 151,893 oz. in the previous year, showing a gain of 32 per cent. The gain was due in part to the larger tonnage of ore milled—which amounted to 175,971 tons, against 140,062 tons in 1902—but more especially to the increased quantity of tailings treated. A notable reduction was made in the costs of mining and milling, and development work has been kept well ahead of extraction. At the close of the year the ore reserves were estimated at 366,000 tons or about two years' supply for the 220 stamps. The profits amounted to £442,000, out of which dividends aggregating 165 per cent on the £260,000 capital were paid. During the last 10 years the company has distributed 1,022.5 per cent on its capital stock in dividends. The Mysore Gold Mining Company during 1903 milled 172,770 tons of ore, and treated 126,646 tons of tailings, yielding a total of 192,897 oz. gold, an increase of 24,393 oz. over the previous year. An additional 30 stamps has been installed in the mill, making 210 heads in all. The dividends paid during the year aggregated £390,389, or 135 per cent. The mine workings have reached an extreme depth of 2,900 ft., and it is said that the values are well maintained.

THE GOLD MINES OF THE KOLAR FIELD.

Mines.	1902.				1903.			
	Rock Stamped. Long tons	Bullion. Oz.	Tailings Treated. Long tons	Bullion. Oz.	Rock Stamped. Long tons	Bullion. Oz.	Tailings Treated. Long tons	Bullion. Oz.
Champion Reef	140,062	141,735	141,651	15,833	175,971	177,361	244,554	31,845
Mysore	140,306	155,577	114,549	12,927	172,770	174,303	126,646	16,813
Ooregum	106,878	71,828	101,460	16,244	141,755	70,822	119,605	13,646
Nundydroog	55,940	52,677	60,409	5,357	66,860	63,525	60,772	6,604
Balaghat	25,635	23,762	24,030	2,635	31,855	24,938	24,800	2,217
Tank Block	22,300	7,895	*Nil.*	*Nil.*	23,153	11,441	*Nil.*	*Nil.*

The Ooregum Gold Mining Company treated 141,755 tons of ore for a yield of 70,822 oz. bullion, and 119,605 tons of tailings yielding 13,646 oz. bullion. This was an unfavorable showing as compared with the previous year due to the falling off in the quality of the ore mined. Exploration is being carried on in the hope of finding new ore-bodies. The Nundydroog mine produced 70,129 oz. bullion from 66,860 tons of ore and 60,772 tons of tailings, a gain of 12,095 oz. over the output in 1902. The crushing capacity was increased to 80 heads. The Balaghat mine made a production of 27,155 oz. and the Mysore West and Mysore-Wynaad mines an output of 11,441 oz. In the Coromandel mine some rich ore has been found on the 1,000-ft. level, and it is expected that the company will resume active operations during the current year.

Korea.—The Oriental Consolidated Mining Company operated its mines throughout 1903 with very satisfactory returns. A total of 203,657 tons of ore was crushed in the five stamp mills for a yield of $709,477 in bullion and 22,575 tons of sulphurets which were valued at $447,623. The income from all sources was $1,203,165, and the expenses $531,072, showing net earnings of $672,093. The operating costs were $2.225 per ton, as compared with $2.73 in the previous year. The report of the general manager states that owing to extraordinary local conditions the mills averaged only 278 days for the year, thereby cutting down the tonnage treated and increasing the average costs of mining and milling. The ore reserves at the close of the year were estimated at 1,058,746 tons with a value of $5,874,637. The exports of gold bullion from Korea in 1903 amounted to £556,985, practically all of it going to Japan.

Madagascar.—The exports of gold during 1903 amounted in value to $1,139,963, equivalent to 55,150 oz. fine, as compared with 38,484 oz., valued at $799,464, in the previous year. The progress of the industry since the French occupation has been rapid, and it is probable that a further expansion will take place as soon as quartz mining is developed. Some promising lodes have already been discovered. The mining laws established by the French government are liberal, making no restrictions against nationality except in respect to natives and negroes. So far almost all the gold produced has been obtained by simple washing processes.

Newfoundland.—The output of gold in 1903 was 6,844 oz., valued at $141,471, as compared with 4,000 oz., valued at $82,680 in 1902. Included in these totals are the gold contents of the copper ores produced by the Tilt Cove, Terra Nova and York Harbor mines, which are estimated to carry values of $2.50 to $3 per ton in both gold and silver. A beginning in quartz mining has been made at White Bay; where the Sop Arm mine has installed a stamp mill and cyanide plant. The placer deposits at Goldenville near Ming's Bight were also worked, but the results have not been wholly successful, owing, it is believed, to the crude methods employed. The production of silver in 1903 amounted to 4,411 oz., valued at $2,560.

Nicaragua.—The exports of gold in 1902 amounted in value to $484,350. There are 103 mines in operation in the republic, most of them being gold mines. They are situated in the districts of Tunki, Pispis, Siuna, Coco, Cincuinta, Rio Grande and La Gapera. The Bonanza mine in the Tunki district has a crushing plant of six Huntington mills and produces about $75,000 a year. The Lone Star mine in the Pispis district is installing a 20-stamp mill. Among other important mines are the Siempre Viva and La Luz y Los Aryeles, the latter being in the Suima district. It is reported that a mining concession covering the departments of Gracias á Dios, Segovia and Jinoliga have been secured by Pittsburg parties.

Peru.—The production of gold in 1903, according to local authorities, was $1,304,610, which compares with $1,750,000 in 1902. The falling off was due largely to the suspension of operations at the Santo Domingo mine and to the smaller return from the ores of Quinua. Mining in the Cerro de Pasco region has shown considerable expansion under the influence of foreign capital. The Chuquitambo company, a British corporation, is engaged in developing a large lode situated nine miles from Cerro de Pasco. The company has installed a 40-stamp mill, which began crushing in October, 1902, and is also engaged in constructing a railroad from Oraya to Cerro de Pasco. The Inca Gold Mining Company, organized by American capitalists, has a 30-stamp mill and its operations are said to be successful.

Russia.—The receipts of gold at the St. Petersburg mint during 1903 amounted to 34,170 kg., which is equivalent to $22,709,382. Making the customary allowance for gold not thus reported, the total output may be placed at $24,980,320, indicating a small increase over the return for 1902. Aside from the districts of Kochgar and Ekaterinburg in the Ural region, where there are some 200 stamps and several Chilean mills working, quartz mining is carried on only in a small way.

According to E. D. Levat the Khanate of Bokhara produces annually about 400 kg. of gold from placers situated along the rivers Varche and Kizel-su, tributaries of the Piandje. The gold is won by natives who employ the most primitive methods and limit their operations to the richest deposits. There is a large area of ground in this region that would repay working by modern hydraulic or dredging installations.

Salvador.—There are four gold mines in operation in the department of La Union. One of the mines, the San Sebastian, belongs to an Anglo-American company. The equipment includes a cyanide plant which has been working for the past two years with good results. Crushing is done in two small stamp mills with an aggregate capacity of 100 tons per day. The ore is said to run from $20 to $1,000 per ton in gold. The Salamanca mine, belonging to an American company, has a new stamp mill, but owing to difficulties with the method of ore treatment the results have not been wholly satisfactory. At the Large Hill mine owned by native capitalists about 20 tons of ore are treated daily by the cyanide process. The ore averages $30 per ton in gold. The Encuentros mines are owned by a foreign company which also operates the Corazal mine in Honduras. They are equipped with a cyanide plant, and the ores contain from 70 to 80 oz. silver and about 2 oz. gold per ton.

South Africa.—Full details of the progress of gold and silver mining in the Transvaal and Rhodesia during 1903 will be found in the review by W. Fischer Wilkinson, on a subsequent page in this volume.

Progress in Gold Milling During 1903.

BY ROBERT H. RICHARDS.

Gold Milling.

Mill at Hodson, California.—H. F. Brown[1] describes the new plant of the Royal Consolidated Mines Company, Ltd., at Hodson, California. The ore is dumped directly into a No. 7½, style D, Gates gyratory breaker, and is crushed to pass a 2.5-in. ring. The capacity is 125 tons per hour. The ore goes to a trommel with 1-in. holes, the oversize going to two No. 4½, style D, Gates gyratory breakers, where it is crushed to 1 in. The crushed ore is raised by belt elevators (64 ft. long, buckets 15 by 30 in.) to the ore bins. The ore is trammed to the mill in cars of a capacity of 4 tons each, drawn by an electric locomotive. The capacity of this line is 100 tons per hour. There are two lines of 12 batteries, of 5 stamps each, arranged back to back. Each battery is driven by a separate pulley, and each unit of four batteries is driven by a separate 50 h. p. motor. The stamps weight 1,050 lb. and drop 106 times per minute. The mortar blocks are of concrete, 6 ft. 6 in. high above the base, 4 by 5 ft. on top and 8 by 8 ft. at the bottom. Each pair of blocks rest on a base 2 ft. 6 in. thick and 12 by 12 ft. square, built on solid rock. Each battery is fitted with copper plates 52 in. wide and 24 ft. long. This excessive length is justified by experience. The concentration machinery consists of 24 Standard tables and 12 vanners, which handle the middlings of the tables. The average capacity is 1,000 tons per day. On prospecting work a profit of $1.99 per ton has been made.

Mill at Allison Ranch, California.—The Allison Ranch mine, California, is described.[2] The mill is supplied with 20 stamps, copper plates and concentrators, and is driven by electric power. The ore is received from the mine in cars and goes to a 30-ton bin near the mine hoist. From here it goes to grizzlies, oversize to a Giant breaker (9 by 15 in.), where it is crushed to 1.5 in., and with the undersize of the grizzlies goes by a belt conveyor to mill ore bins, 240 ft. away. An automatic tipper distributes the ore evenly to the battery bins, which form the 'back knee' of the battery frame, and hold about three days' supply. The ore is delivered to the mortars by James suspended ore feeders. The battery frame is entirely of wood. The mortar blocks are set in pits cut out of solid granite. The mortars are of the medium width, designed for inside amalgamation. The stamps weigh 1,000 lb. and are arranged in groups of five, ten being driven by each cam shaft. The apron plates are 54 by 144 in. and are arranged in movable trays. Launders deliver the crushed ore to four Wilfley tables. A clean-up barrel and retort is provided. Power is supplied by three induction motors, one 15 h. p. motor

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1 *Mining and Scientific Press*, Vol. LXXXVI, 1903, p. 336.
2 *Mining and Scientific Press*, Vol. LXXXVI, 1903, p. 69.

driving rock breaker and conveyor, one 50 h. p. motor driving the stamps and a 5 h. p. motor for the concentrators. Lighting is by electricity.

Milling at Melones, California.—W. W. Bradley[3] describes the Melones Mining Company's plant at Melones, Calaveras county, Cal. Sixty of the 120 stamps in the addition to the mill have been in operation since April, 1902. Water for power is obtained from the Stanislaus River, being carried from the dam, four miles above the mill, in a flume 8 ft. wide and 4 ft. deep, of a capacity of 5,000 miner's inches. It is conveyed under the mill in a 6-ft. redwood pipe, and discharges by means of a tunnel into a pit under the mill floor. At the bottom of a vertical shaft connecting the tunnel with the mill is a 27-in. Victor turbine. The ore coming from the mine goes to the mill bins, and from these is fed to two No. 5 Gates rock breakers. The stamps drop 5.5 in. 104 times per minute, and crush an average of 4 or 5 tons of ore per 24 hours. Challenge feeders are used. The plates are divided plates, 25 ft. long, and have a step of 1 in. half way down. The slope is 1.75 in. per foot. There are 12 tables (one for each five stamps), 9 Wilfley, 2 Halletts and 1 Woodbury improved. The tailings go to the Frue vanners, which are 4 ft. wide. The concentrates are treated direct by agitation cyanide process and the tailings go to waste, being automatically sampled.

Milling Practice in the Black Hills.—Mr. C. W. Merrill[4] describes the treatment of the Homestake ores. The ore is crushed in gyratory breakers at the mine hoist, and varies in size from fines to 4-in. lumps. The crushed ore is trammed to the three mills, Homestake and Golden Star, with 200 stamps each, and the Amicus with 140 stamps. From the mill-bins the ore passes directly to the feeders and stamps. The latter weigh 900 lb. and drop 10.5 in. 88 times per minute. The battery screens are of slot type, No. 8, and the height of discharge is about 10 in. The high, slow drop and high discharge, together with the narrow mortar, produce very fine pulp, 80% passing a 100-mesh screen. Each stamp crushes four tons of ore in 24 hours.

Both inside and outside amalgamation plates are used. Outside there are four full-sized plates, 54 by 144 by 1/8 in., in series, to each mortar. The plate nearest the battery is a copper plate. The others are silver-plated copper plates. From 70 to 75% of the gold is saved by amalgamation. The cost of milling is 40c. per ton in the two 200-stamp mills at Lead. The pulp from the plates is sent to the cyanide plant for treatment.

The Ophir Mill, Colo.—The mine and mill of the Ophir Consolidated Mines Company, San Miguel county, Colo., are described.[5] The method used in milling is as follows:

(1) Grizzlies, oversize to Blake breaker, undersize together with product of breaker goes by belt conveyor to (2).

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3 *Mining and Scientific Press*, Vol. LXXXVI, 1903, p. 52.
4 *Mining and Scientific Press*, Vol. LXXXVI, 1903, p. 150.
5 *Mining and Scientific Press*, Vol. LXXXVI, 1903, p. 135.

(2) Vezin sampler to elevator to (3).
(3) Robins belt conveyor to bins, to (4).
(4) Challenge feeders to stamps, to (5).
(5) Four Wilfley tables; concentrates to bin, tailings to (6).
(6) Spiral sand pumps to (7).
(7) Series of spitzkasten to (8).
(8) Twelve Frue vanners yielding concentrates to bin, and tailings to waste.

There are 50 stamps of 1,000 lb., the batteries driven in pairs by 50-h. p. electric motors. They have plates 12 ft. long. The crushing machinery is driven by a 20-h. p. electric motor and the concentrators also by a 20-h. p. motor. Three Hallett and two Dimmick classifieres have been added recently.

The Alaska Treadwell Mill.—The Alaska Treadwell mine is situated on Douglas Island, near Juneau, Alaska.[6] During the year ending May 30, 1903, 756,325 tons of ore were stamped at a cost for mining and milling, etc., of $1.28, the profits being 91c. per ton. The ore reserve is estimated at 4,287,138 tons. The assay of the ore from 3,700 samples is given at $2.08 per ton. The ore on the lower levels is as free milling as that near the surface, as there has been little oxidation. Of the gold recovered 48.04% is by amalgamation and 51.96% by concentration. The breakers are of the gyratory tpye and are in the head frames of the various hoists. The ore is dumped upon grizzlies, the bars of which are two inches apart. The oversize passes to breakers and the undersize to the ore bin beneath the breakers. The high duty attained by the stamps (4.8 tons per stamp per 24 hours at the old mill and 5.75 tons per stamp at the new) is due largely to the uniform crushing of the ore before it reaches the battery. The stamps are arranged in double rows back to back, the ore being fed automatically and uniformly. Three types of mortars are in use. In the Treadwell 300-stamp, Ready Bullion and 700-foot mills, Fraser & Chalmers 67-A type mortar is used, and the stamps weigh 1,020 lb. In the Mexican the No. 67 mortar is used. In the Treadwell 240-stamp mill a mortar of special type is used, made by Moran Bros., Seattle, Wash., and the stamps weigh 850 lb. End- and side-liners are used in all the mills, and false bottoms are employed in all except the Treadwell 240-stamp mill, where the dies rest on the bottom of the mortar. The false bottoms are of cast iron, 3 in. thick, made in the company's foundry. The Koppel shoe is used in all the mills; it lasts three months and crushes 489 tons of ore, with a loss of 0.27 lb. iron per ton of ore crushed. The dies last 4.49 months, crushing 732 tons, and consuming 0.16 lb. of iron per ton of ore crushed.

At the Ready Bullion, 700-Foot and Treadwell 300-stamp mills concrete foundations capped by cast iron anvil blocks are used, while the Mexican and Treadwell 240-stamp mills have wooden foundations. The life of the latter

6 *Mining Reporter*, Vol. XLVIII, 1903, p. 406. The Engineering and Mining Journal, Vol. LXXVI, p. 659. R. A. Kinzie's original paper, *Transactions* American Institute of Mining Engineers, October 1903.

is about six years. Both water and steam power are used, the relative amount varying according to the time of the year. The water is conveyed in a covered ditch line aggregating 18 miles in length. The free gold is recovered by both inside and outside amalgamation, and the amount of quicksilver consumed varies directly with the size of the screen used. Diagonal slot screens have been adopted in all the mills, and are made of No. 32 gauge heavy Russian iron, and are equivalent to 20 and 18-mesh wire screens. The screens are 9 and 12 in. in width, the 9-in. giving better satisfaction. The apron plates are made of the best Lake copper, 10 by 4 ft., $^3/_{16}$ in. thick, and slope 1.5 in. in one foot. They are dressed twice a day, and the amalgam at the top is allowed to get harder than that at the bottom; thus the lower end can better catch any fine gold that may escape the top. At the lower end of each plate is a wooden trough lined with copper and called the tail box, where very little amalgam is caught. From this the pulp is conveyed through 3-in. iron pipes to the mercury traps, which are 14 in. square at the top, 6 in. at the bottom and 15.5 in. deep, having the shape of a truncated pyramid. From these the pulp flows by distributing launders to vanners. Each vanner has an amalgamated copper plate on the bottom of the feed box, which catches the free gold left in the pulp. Frue vanners are used and are so arranged that two vanners take care of the pulp from five stamps. When a stamp is crushing 5.6 tons of ore in 24 hours each stamp needs 4.25 gal. and the vanner 1.5 gal. of water per minute. The concentrates average 2% of the ore, and run about $51 per ton. The clean-ups are regulated so as to be finished by the 15th of the month.

Gold Milling in Wales.—W. H. Booth[7] states that at the St. David mine 50 heads of 1,050-lb. stamps are in use. During the wet season the machinery is run by a 190 h. p. Pelton wheel, under a 200-ft. head, the water being piped from a distant reservoir. In the dry season the plant is run by a 135 h. p. Tangye gas engine. A steam engine drives the air compressors, and a 50 h. p. Tangye gas engine drives the Elmore oil-concentrating plant. Air is compressed to 80 lb. for rock drills and winches. An overshot water wheel supplies power to drive the clean-up pans. The handling of the ore is automatic from the time the ore is mined till it gets to the stamps. The stamps drop 8 in. 80 times per minute. The screens are 35 mesh. The plate tailings are concentrated by the Elmore oil system, the plant having a capacity of 260 tons per day. The rope tramway, 1,450 yards long, has a capacity of 25 tons per hour and the buckets hold 672 lb.

In the Voel mine of Wales the ore is blende and galena, carrying silver and a little gold. It is crushed to 5 mm. and sized by trommels to 5, 4, 3 and 2.5 mm. and goes straight to 5-compartment jigs. Stuff smaller than 1 mm. is sent to hydraulic classifiers and the products to tables. This plant is driven by a 50 h. p. gas engine.

7 *Cassier's Magazine*, Vol. XXIII. p. 491.

At Gwyn-Fyndd a 40-stamp mill driven by water power is in operation. The details are very similar to those of the first named mine.

Milling Practice in the Transvaal.—Mr. E. D. Chester[8] states that the present practice of gold milling on the Witwatersrand is to crush the ore to pass a screen of 24 to 30 mesh, which (as the feed is 1.5 in.) gives a lot of fines. Experiments were made to decrease the yield of fines, and Mr. Chester recommends crushing with 1,200-lb. stamps, dropping 7.5 in. 94 times per minute, through 10-mesh screens, and recrushing the oversize of 30-mesh (about 14%) by means of a Weyerif pan-roller-mill. Thus the rate of stamping was brought up to 9.29 tons per stamp per 24 hours, from 4.64 tons attained when the direct crushing through 30 mesh was used.

In a general article describing the practice in the Transvaal, John Hays Hammond[9] states that the ore is sorted wet, and 10 to 40% rejected as waste. It then goes through Gates or Blake breakers, is again sorted and 18% rejected as waste. It is then delivered to the stamp bins. The mills are usually large, with as many as 200 stamps. As the gold occurs in the cementing material which encloses the pebbles, fine grinding is unnecessary. The screens have 500 to 900 holes per square inch (or 22 to 30 mesh). Eight tons of water are used for one ton of ore. About 75% of the water is used over after settling, 25% being lost by evaporation and leakage. The average capacity per stamp per day is 4.68 tons. The recent employment of heavy stamps has brought it up to nearly 6 tons per stamp. The cost of a 200-stamp mill to crush 2,000 tons per 24 hours, calling £1 equal to $4.87, is as follows: Mill of 200 stamps, back to back, $238,500; a 45-ft. double tailing wheel, $10,950; 750-h. p. mill engine and condenser, $33,100; 1,000-h. p. boiler plant, $73,100; engine and boiler houses, $14,610; plant for hauling ore to mill, $9,740; water service and reservoirs, $121,800; total, $501,800.

The tailings are elevated by pumps or tailing wheels for cyaniding; the grade of the launder is 3.5%. The wheels are 40 to 50 ft. in diameter. The saving by amalgamation is rarely below 60% of the gold in the ore; in 1898 it was 66%; in 1892 is was 65%. The loss of mercury is small, not over 2 lb. per stamp per month. A few mills use spitzlutten and save 10%, more or less, of the ore in concentrates. The concentrates assay 4 to 5 oz. gold per ton. The spitzkasten takes out 70% more by weight. The cost of concentration is 9d. (18c.) per ton of ore treated. The concentrates of the spitzlutte and the spitzkasten and the fine slime overflow are all cyanided separately. In places chlorination is used at a cost of £2 to £2 10s. ($9.74 to $12.18 per ton) on the heavy spitzlutte concentrates, and saves 98 to 99% of the assay value of the concentrates.

A Free-Milling Gold Run.—Prof. R. H. Richards and E. E. Bughee[10] pre-

8 *Journal* of the Chemical, Metallurgical and Mining Society of South Africa, Vol. III, June, 1903, p. 238.
9 *Mines and Minerals*, Vol. XXIII, September, 1902, p. 58. Paper read before American Institute Mining Engineers, February, 1901.
10 *Transactions* of the American Institute of Mining Engineers, February, 1903.

sented a paper on 'School Laboratory Work; A Free Milling Gold Run.' The tree of the process is patterned after the California mills, variations being made to conform to the small scale work. No battery plates are used. The apron plate is 6 ft. long and 2 ft. wide, and is painted with silver amalgam, one-fourth ounce of silver per square foot of surface being used. The mill is a 3-stamp Fraser & Chalmers prospecting mill, type of 1882, and the stamps weigh 225 lb. A standard 4-ft. Frue vanner made by Fraser & Chalmers, and a canvas table, 4 by 10 ft., covered with No. 6 duck, are used; also a small Wilfley table in the clean-up. The results are comparable with those obtained in the best practice. A result of a run taken at random is here given. The ore is from Nova Scotia.

	Weight, kilos.	Assay, oz. per ton	Gold, %	Gold, grams.	Per cent of the total gold in crude ore
Ore fed	332.6	0.25	0.000857	2.850	......
Battery and ball mill gold	......	......	....	1.9820	76.44
Plate and trap gold	......	......	....	0.0850	3.28
Vanner and Wilfley heads	12.9	0.40	0.001373	0.1769	6.82
Vanner and Wilfley coarse tailings	201.2	0.03	0.0001028	0.2069	7.98
Vanner and Wilfley fine tailings	114.1	0.035	0.0001200	0.1370	5.28
Unaccounted for	4.4	*0.035	0.0001200	0.0053	0.20
Total	332.6			2.5931	100.00

*Assumed for purposes of calculation.

The gold content saved by amalgamation was 79.72%, and in vanner concentrates 6.82%; total, 86.54%.

The assay by fire showed 0.25 oz. gold per ton, and the assay based on mill run 0.227 oz. gold per ton.

A summary of the end results of seven tests is given in the following table, which shows the per cent of the total gold which found its way into each product.

Ore No.	Battery and Ball Mill gold.	Plate and Trap gold.	Vanner and Wilfley head gold.	Vanner and Wilfley coarse tailings gold.	Vanner and Wilfley fine tailings gold.	Loss in handling.	Assay by fire, oz. per ton.	Assay Based on Mill run, oz per ton.
2423	87.40	4.19	3.53	2.96	1.77	0.15	1.03	1.23
2425	5.40	37.72	3.06	41.34	8.70	3.78	0.06	0.08
2444	78.43	5.72	7.68	4.94	2.70	0.53	0.16	0.253
2444	75.16	7.61	8.12	5.29	3.46	0.36	0.15	0.229
2444	76.44	3.28	6.82	7.98	5.28	0.20	0.25	0.227
2444	72.53	8.17	9.39	5.54	4.35	0.20	0.13	0.222
2361	74.84	16.16	1.86	4.13	2.67	0.33	0.13	0.36

Concrete Mortar Blocks.—George S. Binckley,[12] speaking of Mr. Boss's work on concrete mortar blocks for stamp mills, says it is a grave mistake to cut the foundation to receive the sills for the battery posts. He says also it would be much better to have all the mortar bases in one solid concrete block, instead of separate blocks for each mortar, and that the battery posts should terminate at the top of the foundation instead of extending down to the sills.

12 The Engineering and Mining Journal, Vol. LXXV, 1903, p. 514.

High-Speed Stamps.—There is a high speed battery at work at the Meyer & Charlton mine, Johannesburg,[13] which is made possible by a hydro-pneumatic cushion in the stem, the advantages of which are: (1) Ability to run at much higher number of drops per minute than cam stamps; (2) complete elimination of destructive shock and vibration; (3) ability to operate stamps of any weight which may prove to be economically advantageous; (4) reduction of over-crushing and consequent production of slimes. It is claimed that 60 high speed stamps of 600 lb. are equivalent to 100 cam stamps of 1,250 lb.

Dressing Amalgamated Plates.—Mr. W. H. Kritzer[14] gives a number of directions for dressing amalgamated plates.

The Sturtevant Breaker for Gold Mining.—As a preparation for gravity stamps, crushing to ¼ in. size is advocated, and the Sturtevant roll jaw breaker seems to be the machine best adapted to this work.[15]

Hydraulicking and Placer Working.

Hydraulic Plants.—John A. Yeatman[16] is building plants for hydraulicking under artificial pressure. The plant consists of a boiler, an engine, a series-pressure, high-head, three-step centrifugal pump, a giant and an Adams tailings-lift. A 6-in. centrifugal pump gives 250 ft. head, working best at 180 to 200 ft. head. The power is 62 h. p. for 75 in. of water and 82 h. p. for 100 in. of water. An Adams hydraulic lift for the tailings requires five feet of column in the jet for every one foot of lift. Two sizes of nozzles are used. The intake of gravel and boulders is regulated by a gate. An air vent is also provided which aids the work under certain conditions.

Hydraulicking Low-Grade Gravel.—P. Bouery[17] writes on hydraulicking low-grade gravel at one of the plants of California. The water is conducted 30 miles by a flume and ditch supplying 3,000 miners' inches during a period of eight months. In order to utilize this water with profit it is necessary to have several points of attack. All sizes of boulders are met with and have to be removed by derrick, power, etc., according to size. The bank is broken down by four giants, one of 400-ft. head and 7 to 9-in. nozzle in front, two on the left side with 150 to 250-ft. head, and one on the right of 500-ft. head to break up the hard cement. For success the run must be heavy and the sluices kept clean. The bank to be washed fills a gulch with the sides sloping 30°, and varies in thickness from 5 to 250 ft. The entire bank is gold-bearing. As the ground is liable to slide, the giants are worked to prevent it as much as possible. The sluice is 6 ft. wide and 4.5 ft. high. There are 116 boxes (12 ft. long). They slope 8 in. per box. The pavement in the first 10 boxes is of wooden blocks, that in the rest is of boulders which catch the gold very

13 The Engineering and Mining Journal, Vol. LXXVI, 1903, p. 622.
14 *Mining and Scientific Press*, Vol. LXXXVII, 1903, p. 65.
15 *Mining Reporter*, Vol. XLVII, 1903, p. 221.
16 *Mining and Scientific Press*, Vol. LXXXVI, 1903, p. 216.
17 *Mining and Scientific Press*, Vol. LXXXVI, 1903, p. 244.

well. From 2.5 to 3 cu. yd. per 24 hours per miner's inch is the estimated amount washed in the past year.

The cost of operation and returns per miner's inch for a term of years is shown below:

	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.
Cost	$0.136	$0.106	$0.095	$0.1004	$0.866	$0.081	$0.0855	$0.08219
Returns	0.136	0.125	0.136	0.503	0.100	0.0738	0.0665	0.1418
Cost per $1 extracted	1.00	0.85	0.705	0.972	0.862	0.924	1.289	0.5822

Of the expenses 15% is for sluicing and piping, 12% for general expenses, 22% for ditch, 16% for removing boulders. The other 35% is distributed over a number of items incidental to this class of work.

Placer Mining in Colorado.—Arthur Lakes[18] gives notes on the placers of Summit county, Colorado. The Oro Grande Placer Company has 2,000 acres on Blue River, with 13 miles of ditch yielding 2,000 in. of water under 500 ft. head. The average depth is 75 to 80 ft., and the ground runs 30c. per cubic yard. The Evans hydraulic elevator is to be used.

The Gold Pan Mining Company is working ground that runs 46c. per cubic yard. The water is brought from the Blue River four miles distant, one and one-half miles in a ditch 4 ft. deep, 12 ft. wide on top and 8 ft. on the bottom, with a capacity of 7,000 in., and 2.5 miles in an iron pipe 60 in. in diameter. The water is used in giants and Evans elevators, which operate 80 ft. below the surface and raise the water 20 ft. above the surface. The capacity is 6,000 cu. yd. per day, which will be increased to 12,000 cu. yd. The washing season is from May 1 to November 15.

Hydraulicking at Nome.—The first ditch at Nome, built in 1901, was five miles long, cost $5,000 and cleaned up $50,000 in gold.[19] In 1902 the Miocene Ditch Company put in a ditch 27 miles long to deliver 3,000 in. of water, which proved a success in 1903. A water plant consisting of a pumping station with 24-in. pipe-line constructed at a cost of $500,000 has also proved a success. Another ditch to cost $250,000 is in process of construction.

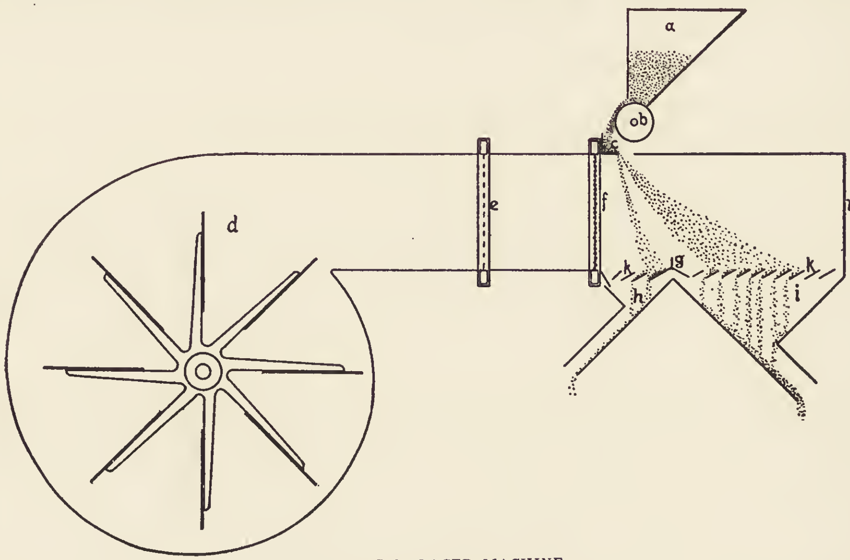
A New Flume.—W. C. Ralston,[20] in a paper read before the California Miners' Association, gives data for a flume built by the Melones Mining Company, Calaveras county, California. The flume is 10,462 ft. long and is built to carry 4,000 miners' inches, and cost $28,591.

Dry Concentrating.

The Edison Concentrator for Gold.—Cloyd M. Chapman[21] describes Edison's dry process for separating gold from gravel. The machine was made

18 *Mines and Minerals*, Vol. XXIII, 1903, p. 241.
19 *Mining and Scientific Press*, Vol. LXXXVI, 1903, p. 164.
20 The Engineering and Mining Journal, Vol. LXXV, 1903, p. 785.
21 The Engineering and Mining Journal, Vol. LXXV, 1903, p. 713.

to work a very rich placer situated at the foot of the Golden Mountains, New Mexico, 35 miles from Santa Fé. The conditions the machine had to meet were: Ability to give continuous steady blast throughout its entire cross-section; to feed all particles at low velocity to blast; and to feed the particles so that there should be no variation beyond certain limits. A steam shovel excavates the gravel and deposits it on a grizzly spaced to allow the coarsest size of gold to fall. The oversize is rejected. The undersize is hauled in cars to the mill and dumped into storage bins, and from these fed to the sizing house, where it is made into from four to eight sizes. These sizes are each



EDISON DRY PLACER MACHINE.

sent to a separator adjusted to treat the special size it handles. Two conveyors carry the products away, the tailings to the dump, and the concentrates to storage house or Edison magnetic separators, which take out the magnetic black sand from the gold. The amount of gold saved varies from 77 to 99%, according to the size of the product. With from 3 to 35c. of gold per cu. yd., the average saved was 92.5%.

The Freid Separator.—Douglas McLean[22] writes on the Freid gravity dry process separator. This is essentially the same as the Edison machine, and depends on gravity and deflection for its successful working. The ore drops through a hopper upon a feed roller and encounters a current of air formed by an exhaust fan in the further end of the machine. The heavier particles are deposited near the feed end and the lighter ones, according to weight, are distributed toward the end of the machine. One mill at Orange, N. J., has a full unit at work, and it is claimed concentrates 500 into 1 with a saving of 95% of the gold values.

22 The Engineering and Mining Journal, Vol. LXXVI, 1903, p. 970. Illustrated.

A Dry Concentrator.—F. B. Allen[23] has made tests on a dry concentrating machine for gold invented by C. W. Phillips. The machine consists of a fan-blast classifier for grading the sand and separating the dust, and a dry vanner for separating quartz from the gold. The vanner is similar to the Frue. Good results were obtained.

Method for Saving Flour Gold.—R. P. Hall[24] of Gem, Idaho, has patented a scheme for saving flour gold. He first separates by screens the fine material which passes over a series of specially designed copper trays carrying quicksilver. Gravel with 83c. gold per cu. yd. yielded by treatment tailings with only a trace of gold. The machine has a capacity of 25 tons sand per day. A company is being organized to manufacture machines and secure rights in northern Idaho.

Gold Dredging.

A New Dredge for British Columbia.—The Western Engineering & Construction Company, of San Francisco,[25] are building a dredge for shipment to the Atlin district of British Columbia. It is to be shipped by way of Skagway, Cariboo and Tagish Lake. The power will be generated by water two miles from dredging ground and transmitted by electricity. The machinery includes a chain-bucket elevator for lifting the gravel, steel hopper for receiving the gravel, revolving screens for removing the boulders, a sluice box for saving the gold, sluices for the fine tailings and elevator for fine tailings in case of need. The Atlin gold is coarse and easily saved, but the dredge will be provided if necessary with gold-saving tables for fine gold. The electric plant includes two 180-kw. belted alternators driven by water wheels, two type F variable speed induction motors with controllers, two standard type C induction motors, 20 and 50 h. p. respectively, for the pump, and one of 15 h. p., type C, for the screens.

A Dredge for Alaska.—A. W. Robinson[26] describes a dredge built for Mr. W. Ogilvie for the Stewart River, Yukon district, and installed at the end of the summer of 1902. It can work 25 ft. deep at the rate of 75 cu. yd. per hour. It has been made light and strong on the sectional plan for easy transportation, forged and cast steel being used, with least possible amount of cast iron. It is also made as simple as possible with the fewest parts. The boat is 85 ft. long, 25 ft. wide and 4 ft. 6 in. deep. It is designed to work in a river with a current running 9 or 10 miles per hour. It has a chain-bucket system, buckets holding 2.25 cu. ft. It belongs to the coarse-screen sluice box type, with screen 38 in. in diameter and 14 ft. long, differing from the New Zealand type with fine screen and tables for catching fine gold. The main engine is a vertical duplex steam engine with 8 by 8 in. cylinders and a single

23 *Australian Mining Standard*, Vol. XXIX, 1903, p. 597.
24 *Mining Reporter*, Vol. XLVIII, October, 1903, p. 309.
25 The Engineering and Mining Journal, Vol. LXXV, 1903, p. 411.
26 The Engineering and Mining Journal, Vol. LXXV, 1903, p. 670.

return tubular boiler 54 in. diameter and 14 ft. long, using inferior wood for fuel. Space is left for tables in case they are needed.

Newton B. Knox,[27] in abstracting the paper, writes: The Oroville district has a gravelly bottom, 9 miles long by 2 miles wide, contiguous to the Feather River. There are 21 dredges in operation, owned by 12 companies, each controlling 80 to 800 acres. They pay good dividends; in one case all expenses were covered by 32% of the bullion output, leaving 68% as profit. Valley gravel averages about 17 to 19c. per cu. yd. and is 11 yards deep. The dredges work 1,200 to 2,000 tons per 24 hours. The cost is 5c. to 8c. per yard, or an average of 6c. The top gravel lies on false bed-rock of lava more or less decomposed, with gravel beds below. The gold is confined to the top gravel. Boulders are small, rarely weighing 300 lb., and the gravel is generally not cemented. The gold is fine in size and is caught on tables with riffles, or cocoa matting and expanded metal, and runs 922 fine or $19 per oz. The gold recovered by dredges is somewhat lower, due to presence of gun shot.

The Oroville district is peculiarly favorable to dredging for the following reasons: (1) The lava bed-rock is soft and easily cut; (2) the boulders are small; (3) plenty of water is available; (4) electric power is cheap; (5) gold is fairly evenly distributed; (6) the climate is favorable for working 12 months in the year; (7) labor is cheap and efficient; (8) the gravel contains enough gold to pay well.

The land is divided into blocks of 5 to 10 acres, and a hole is put down in the centre of the block. The tool used is a portable well-drilling plant with engine, hoisting drum, walking-beam and string of tools. The bit is 5.5 in. wide; the drilling is done through the gravel, with the aid of a casing or pipe which is driven down as the hole progresses. The sand pump, which lifts out the drillings, lifts also the gold. The gravel from discharge of each sand pump is washed in a rocker, the gold weighed, the sand measured and the depth recorded; in this way a reliable section of the deposits is obtained, giving depth and richness of the gravel (in cents) per cubic yard. The cost of drilling is $2.50 per foot. The general cost and yield may be expressed as follows: With gravel 11 yd. deep, and 21.28c. per cu. yd., the total value in a 200-acre tract is $2,218,000. The land may cost $150,000. The 5-ft. bucket dredge costs $65,000 and the working capital required is about $10,000; total, $225,000. The total value in the land, $2,218,000, will be cut down by a loss of 1c. per yard left in the tailings to $2,118,000, and again by the cost of treatment of $714,000, to a net yield of $1,314,000, requiring 17 years for its production, or an annual yield of $77,300, which would be divided into a sinking fund of $10,300, for making good the investment, and dividends of $67,000 per annum, or about 30%.

27 *Mining and Scientific Press*, Vol. LXXXVII, 1903, p. 20. The Engineering and Mining Journal Vol. LXXVI, 1903, p. 318. From 'Dredging in Oroville,' *Transactions* of the Institution of Mining and Metallurgy, London, June 18, 1903.

Dredging in New Zealand.—F. W. Payne reviews the history of dredging in Otago, New Zealand. The original method of working the gravel was by rocker; later the spoon dredge was tried, its product being washed in a cradle. Finally the continuous chain of buckets was adopted, which is the method of the present time. At first two ladders, one on each side of the boat or pontoon, were tried, but they caused great oscillation of the pontoon. This arrangement quickly gave way to the single chain of buckets placed in front of the pontoon. Current wheel dredges were tried, but are mostly abandoned because of small power and the fact that they cannot work near the shore out of the main current. The regular dry land dredges are the outcome of this development. The Kawaraw bridge gold dredge has a pontoon 105 ft. long, 26 ft. wide and 7 ft. deep.

The Sandy point gold dredge, designed by F. W. Payne in 1899, has buckets with capacity of 7 cu. ft. Power is supplied by a multitubular boiler, externally fired, at 150 lb. pressure. The dredge works to 40 ft. below water line and can stack tailings 40 ft. above it. The tailings elevator is 82 ft. long between centers. This elevator has been replaced by a Payne-Peck centrifugal elevator, which throws the boulders and sand by high speed revolving fans upon the tailings dump. The use of the centrifugal elevator in one case saved £4,500 to £5,000 in first cost and reduced the expense of repairs. The average dredge treats 100 to 120 tons per hour; about 25% of this goes to the tables. The best tables have canvas beneath, cocoa matting upon this and expanded metal above. The working of the tables is more unsatisfactory where black sand abounds; in such cases they are liable to choke with the black sand, or, if more water is used, fine gold is lost.

The dredging business has in general proved profitable; most of the failures have been due to insufficient capital. The average capital of dredging companies is £7,00 to £8,000, and the cost per week 12 to 14 oz. of gold.

Results with Different Dredges.—Ralph L. Montague[29] compares some of the different dredges as to capacity, horse power and cost. His conclusions are embodied in the following table:

Type.	Size of Buckets. cu. ft.	H. P. Required.	Average Capacity. per 24 hrs. cu. yd.	Yards per 24 hrs. per H.P.	Cost Wages. per day.	Cost Power.	Cost per yd.
American, open connected.....	5	120	2,300	19	£6	£4	1.04d
New Zealand, open connected.....	3	50	600	12	3 18s.	1 13s. 4d.	2.03d
American.. close connected.....	5	170	3,200	18.8	......	......	......
Shovel...............	1¾ yds.	160	500	3.1	......	......	......

28 *Transactions* of the Institution of Mining Engineers, Vol. XXIII, 1901–1902, p. 532.
29 *Canadian Mining Review*, Vol. XXII, 1903, February, p. 35.

A Review of the Cyanide Process During 1903.

BY CHARLES H. FULTON.

A number of improvements in the cyanide process have been introduced during 1903 and are now being tested in various mills.

Charging and Discharging Tanks.—Among the most important innovations is the Blaisdell cyanide vat excavator and the centrifugal pulp distributor. The excavators and distributor work on the principle of the disk harrow. These machines were described by Butters and Crank.[1] The excavators find their application where sluicing is out of question, or where its cost is considerable. Plants with these machines have been installed at Virginia City, Nevada, at the Gold Road Mining & Milling Company, at Acme, Arizona, and by El Oro Mining & Railway Company in Mexico.

Treatment of Slimes.—A new method of slime treatment has been evolved by Mr. Charles Moore, which promises well. It has been tried successfully at the large mill of the Mercur Consolidated Mines Company, Utah, and is being installed by the Dexter Mining Company, at Tuscarora, Nevada, and by Lundborg, Dorr & Wilson, near Terry, S. D., in the Black Hills. At this plant it has been in successful operation for about five months, treating 25 to 30 tons of slimes per day. Other Black Hills plants are experimenting with the method. The process consists of immersing filter frames covered with canvas in the slimes, and employing suction on the inside of the frames so as to cause the slimes to adhere to the outer surfaces of the frames in thin layers. The frames, with the slimes-cakes, are then transferred into weak cyanide solution and water, successively, being washed by drawing the solution through them by suction. Then the slimes-cakes are caused to peel off by changing the suction to pressure. The advantages of the process are compactness of installation and the discharge of comparatively dry slimes. The cost of treatment is low. The system is described by George Moore.[2]

Filter-pressing of slimes finds but little application in this country. The Confidence mine, in Tuolumne county, Cal., employs a filter-press in slimes treatment, as does the Greenback mine in southern Oregon. The Sunshine mill in the Mercur district, Utah, which has a filter-press plant, is idle at present. The Black Hill plants (the Homestake and Horseshoe mills) are experimenting with the filter press for slimes treatment.

The Argo continuous filter-press is an innovation in the treatment of slimes. It consists essentially of a traveling belt of cloth on which the slimes are fed. This cloth passes, in one place, over the opening of a vacuum chamber, where the solution is sucked from the slimes, the dried slimes (containing 13 to 15 per cent moisture) being removed from the belt by scrapers.[3]

At the Homestake experimental plant at Lead, S. D., some very interesting experiments relative to slimes treatment have been made by the De Laval

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1 The Engineering and Mining Journal, December 5, 1903.
2 *Ibid.*
3 The Engineering and Mining Journal, October 17, 1903.

Company with centrifugal separators. The slimes-pulp is fed to a centrifugal separator which concentrates the pulp so as to increase the percentage of sulphides. The concentrated material is mixed with cyanide solution in an agitator and is then separated from the slimes by re-treatment in the separator. The washing with water is done in a similar way. The slimes are said to be discharged with only 3 to 5 per cent moisture. A difficulty to be overcome is to make the operation continuous, and the method gives no great promise at present. The centrifugal separator is also employed in the Elmore oil concentration process.

Any slimes treatment process is of considerable interest to cyanide metallurgists. At present the decantation process is applied extensively in the Black Hills and elsewhere in the United States, but its imperfections are evidenced by the eagerness with which cyanide men turn to any new slimes process.

Just what constitutes a 'slime' has been under discussion by metallurgists recently. The tendency is to not refer to the size of particles, but to such physical properties as prevent the percolation of solutions.[4]

Crushing of Ore Preliminary to Cyanidation.—Direct wet-crushing of ore in cyanide solution is still in the ascendency, whenever the nature of the ore permits of it. Most mills of this type crush with stamps, but during the year the Bamberger-De Lamar plant, at De La Mar, Nevada, the Lassen Mining Company, in Lassen county, Cal., and Lundborg, Dorr & Wilson, at Terry, S. D., have installed the Monadnock roller mill for crushing. At the De La Mar plant twelve 6-ft. mills are in operation, which crush about 46 tons each through a 30-mesh screen in 24 hours. The ore is largely a hard quartz. A lower consumption of power is claimed. One of the chief advantages, at least for small mills, is the lesser cost of installation. The wear of metal is the same as in stamps, and as regards the product made, it contains less slimes than the product of the stamp-mill.

The Refining of Precipitates.—More attention is paid to the refining of precipitates since it has been realized that considerable loss takes place in the ordinary operations. The method in use at the Homestake mills represents a distinct advance. The precipitates from the filter-presses are treated first with hydrochloric acid to remove the lime salts, and then with sulphuric acid. The supernatant liquid in each case is forced through filter-presses to remove suspended gold. The acid-treated precipitates are also forced through the press and washed, then removed and partially dried, mixed with fluxes, litharge and powdered coke, and finally briquetted. The briquettes are fused in a cupelling furnace to lead bullion and slag, the bullion being later cupelled. The slag is re-treated with litharge in a small blast-furnace, as described by C. W. Merrill.[5]

At the Penobscot mill, at Maitland, S. D., the sulphuric acid from the

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4 The Engineering and Mining Journal, issues for October, 1903.
5 The Engineering and Mining Journal, March 7, 1903.

treatment of the precipitates was run through a tank containing the waste zinc fines from the zinc lathe. This tank, when cleaned up after about four months' run, yielded over $1,000 in bullion, whether from gold in solution or suspended gold is uncertain. The Penobscot mill is a modern one and its clean-up facilities are excellent, showing that there is certainly room for improvement in the method generally employed.

Amalgamation after Cyanidation.—Two mills crushing in cyanide solution have installed plates to catch free coarse gold not taken up by the solution. These plates are situated so that the tailings can be sluiced over them. Plates of this type are said to be in successful operation at the Annie Laurie mill in Utah. The same scheme is being tried at the Hidden Fortune mill, below Deadwood, S. D. There a special device, consisting of a distributor with finger-boards, is employed in endeavoring to get a uniform flow over the plates. The device is not successful, and experiments are now being made to crush with a very weak cyanide solution (1.5 lb. per ton) and lead the pulp over plates in front of the mortar as in the ordinary amalgamation process. While the amalgam is harder than usual it still is not sufficiently so to make the method a failure.

Cyanide Poisoning.—According to Martin and Jenkins, hydrogen peroxide, advocated much at one time as an antidote in case of cyanide poisoning, is in all cases inefficient on account of its slowness of action. Ferrous sulphate with oxide of magnesia and dilute potash solution was found to be the most efficient antidote.[6]

Regeneration of Waste Solutions.—Many mills are endeavoring to get a satisfactory method to regenerate potassium cyanide from waste mill solutions. The Smuggler Union employs the Davis process for regeneration successfully. The Camp Bird mill, also in Colorado, has a recovery process in operation which is said to be successful.

World's Production of Gold by Cyanidation.—According to G. T. Beilby, the world's production of gold bullion by cyanide process in 1900 was 1,826,053 oz. of bullion. During that year the Transvaal produced but 85,000 oz., owing to the war in South Africa. The production of mill bullion by cyanidation in the United States during the same year was 497,280 oz.

General Review by States: Arizona.—Cyanidation has made considerable progress in this region. The largest plant constructed and placed in operation during the year is that of the Gold Road Mining & Exploration Company, at Acme, Mohave county. The capacity is 200 tons per day. The ore is crushed by rolls, a separation of dust being made by dry separators, the dust being treated separately in agitation tanks. The sands are treated in sixteen 30-ft. leaching vats in the open; the crusher house, precipitation boxes, and engine and boiler rooms alone being enclosed. The vats are charged by means of belt-conveyors and Blaisdell distributors.

In the same county, at Gold Basin, the Cyclopic mine is installing better

6 The Engineering and Mining Journal, August 8, 1903.

cyaniding equipment. In the Cedar district the Yucca Mining & Milling Company is operating a 50-ton plant, and in the Weaver district the Virginia mine is adding a mill.

In Maricopa county, the Socorro mine, west of Wickenburg, has placed its new milling plant with cyanide annex in operation.

In Yavapai county, the plant of the Congress Gold Mining Company has been active; 80 stamps are wet-crushing the ore, consisting of white quartz and pyrite and having an average value of $15 per ton. The pulp is concentrated on tables and the tailings are separated into coarse sands and slimes. The sands are leached directly, and the slimes are roasted and then cyanided. The capacity of the plant is 300 tons per day. At Rich Hill the Octave mine has a plant in operation stamping and amalgamating 130 tons per day, then concentrating and cyaniding the sands of the tailings. West of Prescott, the Hillside group of mines has a small mill and cyanide annex in operation. The Gold & Copper Mining and Milling Company also has a small plant at work near Prescott.

Near Val Verde, at the Iron King mine, the American Copper Company has constructed a small cyanide mill. In Santa Cruz county, the Gold Rock Consolidated Company at Oro Blanco is installing a cyanide plant.

California.—In this State cyanidation has been active; the largest new plant constructed during the year is the Sand Pile mill, near Forrest Home, Amador county, to treat the great quantity of old tailings from the Plymouth Consolidated mills, running in value from $1 to $2 per ton, and carrying considerable slimes and fine sulphides. The plant cost between $30,000 and $40,000. In San Benito county, at Ludlow, the Bagdad Mining Company is adding a 200-ton mill as an adjunct to plate amalgamation.

In Kern county, at the Esther group of mines, a 100-ton mill with rolls for dry-crushing is under construction. At Randsburg the Stanford plant has added a cyanide mill, and the Echo mine is constructing a mill at Mohave, where the Exposed Treasure mine is also operating a small plant.

In Alpine county, the Curtz-Evans Mining & Milling Company has a new 50-ton pneumatic cyanide plant.

In San Diego county, the California King Gold Mining Company's 1,000-ton plant at Picacho has been in operation part of the time, treating 350 tons per day, and at Hedges the tailings plant of the Gold Fields of California, Ltd., formerly the Free Gold Mining Company, is to enlarge its tailings plant from 300 to 1,000 tons per day.

In Mono county, the Standard Consolidated and the Del Monte plants have been in operation.

In Lassen county, the Lassen Mining Company has erected a 70-ton plant, crushing the ore in roller mills previous to cyaniding.

In Plumas county, the Plumas Gold Mining Company has installed a cyanide plant as an adjunct to a 15-stamp amalgamation mill.

In Tuolumne county, at Jamestown, the Rawhide mine has enlarged its cyanide capacity to 100 tons, and is treating pyritous concentrates by cyanidation in place of chlorination. The Mount Jefferson mine near Groveland also treats concentrates by cyanidation. The new 100-ton tailings cyanide plant of the Confidence mine has been placed in commission. Near Columbia, the Dinsmore mine has kept its cyanide plant busy.

In Siskiyou county the cyanide mill of the Helena Gold Mining Company is at work treating 60 to 70 tons per day, and near Gazelle the Dewey mine is operating a 10-stamp mill with cyanide annex.

In Mariposa county, at Mount Bullion, the McLeish tailings mill is to increase its capacity from 30 to 70 tons per day.

In San Bernardino county the Gold Peak Company, at Victor, has installed a small cyanide annex.

In Inyo county, the Anvil Springs Mining Company, at Anvil Springs, has constructed a small plant.

Colorado.—No new plants of any size have been constructed in this State during the year.

The Sanger Mining & Milling Company, at Jasper, has erected a 100-ton pneumatic cyanide plant, and the Wano Mining & Milling Company, at Jamestown, Boulder county, has a 50-ton pneumatic cyanide plant. The ore at this place is dry-crushed and roasted in part.

In the same county the Magnolia Mining & Milling Company is remodeling the old Nellie Bly mill for cyanidation.

In Fremont county, at Querida, the new Bassick mill concentrates the ore and cyanides the tailings.

In Gunnison county, the Jersey Blue mine, at Ohio, has a 25-ton pneumatic cyanide plant in operation.

For the higher grade, unaltered, milling ores of the Cripple Creek district, chlorination has the preference, the Dorcas mill at Florence being the only cyanide mill in operation. Interesting work, however, is being done in a number of small mills in Cripple Creek on the low-grade oxidized ores. The Globe Reduction Company (Temple & Ross) has converted the old Van Fleet sampler near Goldfield into a cyanide plant employing coarse crushing and cyanidation without roasting. This mill is said to be in successful operation on ores from the Ironclad mine. There is also a small plant on the Magna Charta, on Ironclad mill, erected by the Cripple Creek, Homestake, Mining & Reduction Company to treat the mine dump without crushing.

On Copper Mountain, the Lois mine has a small plant with crushing rolls and four 85-ton leaching tanks. At Colorado City, the Colorado & Philadelphia mill has resumed operations after a labor strike, and is treating Cripple Creek tailings. The Bi-metallic mill at Cyanide has been dismantled.

At Colorado City, the Telluride Reduction Company's mill has been in operation part of the time, employing bromine in conjunction with cyanide. This, however, is more properly a bromination mill.

In Ouray county the new cyanide plant of the Camp Bird mine has been in steady operation, treating 150 tons of tailings per day, although its capacity is 200 tons. Only the sands are treated at present, the slimes being accumulated by tailings dams. The cost of cyaniding sands is 73c. per ton, according to Messrs. Woods & Doveton.

In San Miguel county the operation of the Liberty Bell and Smuggler-Union mills has been intermittent, owing to unsettled labor conditions.

At Leadville, on Brecce hill, the Ballard mill, a 50-ton experimental plant, has been erected to treat the low-grade silicious iron sulphide ores, but with what success is not known. Experiments have also been carried on with Clear Creek county ores, and several large plants are projected.

Montana.—Cyanidation has been very active, especially in Fergus and Madison counties. In Fergus county the mill of the Gold Reef mine at Gilt Edge has installed two roasting furnaces, and the Barnes-King mills have made changes in their screens, etc. The Kendall mills have been treating a large tonnage of \$6.50 ore. The Chicago & Montana Company, in Whiskey gulch, has put its plant in commission. The output of gold by cyanidation in Fergus county for March was \$71,095 and for November \$74,411, showing a steady increase. Several new plants are projected in this region.

In Madison county, at Norris, the Revenue Mining Company is building a 100-ton plant, and at Virginia City the Kearsarge mine has a 60-stamp mill with cyanide annex under construction. At the Eastern mine, the stamp-mill and cyanide annex have been put into operation.

In Park county, at Jardine, the Kimberly and Montana Gold Mining Company has erected an 80-stamp mill with cyanide annex, which is now at work. The Revenue Mining Company also has a plant under construction.

In Lewis and Clarke county, in the Marysville district, the Montana Mining Company has had its tailings plant in operation, and the Jay Gould mine of the Standard Ore Company is building a 30-stamp mill and cyanide annex. Two other plants are projected.

In Choteau county, at Landusky, the Alder Gulch Mining Company has completed a 100-ton cyanide plant, which is now at work. Plants are projected in Jefferson, Granite and Sweet Grass counties. In Deer Lodge county, the New Southern Cross Company has a plant under construction.

According to the United States Assay Office at Helena, the production of gold by the cyanide process in Montana for 1902 amounted to 50,402 oz. fine, equal to 23.6 per cent of the total gold production of 212,855. The increase in production by cyanidation over 1901 was 5,445 oz.

Idaho.—In Idaho county the Valley Creek mine has added a cyanide annex to a small stamp-mill. At Buffalo Hump several plants are projected. In Lemhi county, at Ulysses, the Kittie Burton Mining Company has increased the capacity of its stamp mill and added a cyanide annex. At Leesburg the Gold Dust mine is erecting a 10-stamp mill and adding a cyanide annex.

At Bear, the Idaho Gold Coin Mining & Milling Company has constructed a 50-ton dry-crushing plant, which was destroyed by fire in October, but is to be rebuilt.

In Shoshone county, at Pierce City, the Wild Rose mine has erected a small cyanide plant. The Grant & Allie Mining Company has a 10-stamp mill and cyanide annex at work. The New Jersey Mining Company near Wardner tried an electric amalgamation-cyanide process without success. At Custer City, the Lucky Boy Mining Company has a cyanide plant in operation.

At De La Mar, the De La Mar mill, the largest in the State, has been working continuously during the year.

New Mexico.—In Taos county, at Woody, the Glen Woody Company is building a mill and cyanide annex, containing rough crushers, Huntington mills, settling vats and cyanide tanks. In San Miguel county, at Tecolote, Buck & Elliot are operating a 25-ton plant. In Socorro county, on the east side of the San Mateo range, at the Rosedale mine, W. H. Martin & Company are operating a 10-stamp mill and cyanide annex. Other plants are projected in Taos and Grant counties.

Nevada.—A new plant to go into operation in Nevada is the 275-ton mill of Charles Butters & Company, to treat old Comstock tailings and ore from the Comstock mines.

The mill of the Bamberger-De Lamar Company, at De Lamar, has been entirely remodeled and started to work in June. At Tuscarora, Elko county, contracts have been let by the Dexter Mining Company for the installation of the Moore slimes process.

Oregon.—The Greenback mine, in the Grave Creek district of southern Oregon, is operating a 40-stamp mill and a 100-ton cyanide annex, with a filter-press plant for treating slimes. In Baker county, the North Pole mill was active part of the year, dropping 30 stamps and employing nine percolation vats and six agitation vats. In Grant county, the Red Boy Consolidated mill is shut down pending further mine development. In Okanogan county, at Bodie, a 50-ton amalgamation and cyanide plant are in course of erection.

South Dakota.—Cyanidation has made distinct progress. The new mills that went into operation during the year are the 600-ton plant of the Horseshoe Gold Mining Company, at Terry, treating at present 300 tons per day; the Hidden Fortune mill, below Deadwood, treating 200 tons per day; the Jupiter mill, in Blacktail gulch, treating about 100 tons per day; the Penobscot mill, at Maitland, treating 150 tons per day, and the Golden Crest, in Strawberry gulch, treating 40 tons. Only one new mill has been constructed, the Lundborg, Dorr & Wilson mill, near Terry, which has been in operation since last January. The old Union Hill Company's mill near Galena is being remodeled with a cyanide annex. In Deadwood the Golden Reward plant has been in operation during the year, the Dakota plant and the Imperial plant have resumed operations, and the Rossiter plant is idle. Owing to the high local freight rates on ore, there is a general tendency to place the new mills near the ore supply. It is possible that the Dakota mill will be moved to the mine in the near future. In the Ragged Top district the Spearfish and Deadwood Standard mills have been in steady operation, the former having increased its capacity to about 300 tons per day. In the Yellow Creek district the Wasp No. 2 mill has been steadily at work, treating 125 tons per day. The Alder creek mill has been shut down since June, 1903. The large tailings plants of the Homestake Company at Lead and Central have been in operation throughout the year. The Lead plant of the company is being enlarged to take the tailings from 100 new stamps in the Highland mill. Several other large plants are projected for the Black Hills. At present 14 cyanide plants out of 20 are in operation, treating approximately 3,800 tons of ore and tailings per day.

Utah.—No new plants of any size have been erected in this State during the year. The plant of the Mercur Consolidated Gold Mines Company has been in operation. During the fiscal year 1902-1903, it treated 335,163 tons of ore, averaging $5.05 per ton, the extraction being $3.84 per ton, and the tailings averaging $1.21 per ton. The cost of milling was $1.58 per ton and of mining $1.30 per ton. The tailings have increased in value from 95c. in 1901 to $1.30 during the first half of 1903, owing to the talcose nature of the ore. This fact led to the installation of the Moore slimes process, which is said to be in successful operation, reducing the average value of the tailings materially. The Sacramento mill in the Mercur district has been in operation throughout the year. A portion of the ore is retorted for mercury previous to cyanidation. The Annie Laurie mill in Piute county has also been active.

Metallurgical Progress in Western Australia.

BY ALFRED JAMES.

It is no small matter for a gold-field to be able to claim to have reduced its treatment cost by 25 per cent in one year; but at Kalgoorlie the managers of the leading properties are not only in a position to make such a claim, but to substantiate it fully.

While the completion of the fresh-water scheme has notably aided the management in their efforts, so brilliant a result is undoubtedly due to the high technical skill and intelligently directed energy which has been brought to bear on the problem, and also to the keen but good-natured rivalry between the "all-roasting" and "combination" processes, which has done not little towards the achievement of such creditable work.

Last year, in stating the treatment costs of some of the best managed mines, it was shown that the Great Boulder Main Reef, with an average treatment cost of 25s. a ton, had been able to lower it in its best month to 21s. per ton, and in this it was closely approached by the Hannan's Star company. On richer ores, such as those of the Hannan's Brownhill and Lake View Consols, the costs were no less than 32s. 9d. for treatment, of which bromo-cyanide alone accounts for as much as 8s. per ton.

The first two of the above companies have now, however, reduced their treatment costs to under 16s. per ton, and it is most interesting to note that these two companies are neighbors, have mills of nearly the same size—the Hannan's Star putting through perhaps 25 per cent more ore than the Great Boulder Main Reef, and thus having the advantage of distributing its costs over a greater quantity of ore—and in spite of their comparatively small output they usually manage to show the lowest treatment costs on the field, each being the pioneer of the roasting and bromo-cyanide practice, respectively.

For October, the Great Boulder Main Reef held indisputably premier position; for November, Hannan's Star was able to reduce its costs to under 16s. per ton, and thus to nearly get even with the Great Boulder Main Reef figure for the previous month.

But such mines as the Great Boulder Proprietary, the Lake View and the Oroya Brownhill, are in no way behindhand in also accomplishing considerable reductions, although their costs may not be as low as those of the two companies referred to. The Lake View costs for July, 1902, were 25s.; they have now been reduced to 17s. (per long ton). The Great Boulder Proprietary costs in 1902 were 23s.; as late as May, 1903, they were 19s. 6d.; by January, 1904, they were 17s.

It may be asserted that these expenses are still high compared with treatment-costs in other regions, but it must be remembered that the Kalgoorlie charges are for the treatment of a complicated and difficult sulpho-telluride ore, which it has now been practically universally admitted must be roasted—at least in part—as well as receive other special treatment.

That the engineers in charge are not one whit behind the rest of the world in their effort to secure economy is shown by the Great Fingall mine, which is directed by the same engineering firm as controls the Great Boulder Main Reef and the Lake View companies; the total expenses at the Great Fingall are only 20s. per ton for mining, management and ore treatment complete, the latter item being only one-half of the lowest costs at Kalgoorlie.

Before leaving the subject of costs, it will be proper to give details; these are as follows, per ton: Crushing, 6d.; milling, 2s. 6d. to 3s. 9d.; roasting, 3s. 0d to 4s. 0d.; amalgamation and grinding, 1s. 6d. to 2s. 6d.; agitation and cyaniding, 2s. 6d. to 7s. 6d.;[1] pressing, 1s. 0d. to 2s. 0d.; disposal of residues, 9d. to 1s. 1d.

A year ago, in referring to this same subject, I stated that of all the processes put forward at Kalgoorlie, the "roasting" and "Diehl" had alone survived, and that the latter process would probably disappear as such in favor of a combination process in which the refractory portion of the ore would be concentrated out and roasted, amalgamated and cyanided; and the unroasted slimed tailings either treated by cyaniding alone or, if they contained more than 0.5 per cent sulphides, with the addition of bromo-cyanide. This prognostication has now been completely verified. The Diehl process, as such, survives

1 The latter figure is on Oroya Brownhill rich ore and includes 2s. 6d. per ton for bromo-cyanide and 3s. for cyanide.

at Hannan's Star alone, the low-grade ore of which—as stated by the writer whenever he has referred to bromo-cyanide—made it just one of the propositions for which the Diehl process was particularly suitable, because the practical difficulty or impossibility of obtaining absolute high extractions by bromo-cyanide treatment alone has caused its use to be generally limited to pulp containing under 0.5 oz.; and it will be noted that the high extractions claimed where bromo-cyanide is employed are the result in each case of the percentage recovered by amalgamation or by roasting. Thus, at the Hannan's Star the actual extraction obtained by bromo-cyanide is between 80 and 90 per cent only, the balance being recovered by amalgamation; and at the Lake View the extraction on the material actually bromo-cyanided is only 81.5 per cent, whereas the extraction on the richer material roasted is 98.7 per cent, and it is this latter extraction (which is responsible for over half the output) which brings the average extraction for the whole treatment up to the 90 per cent claimed.

The success, however, of the combination process—and it might appropriately be called the "Bewick Moreing" or "Prichard" process—which has taken the place of the original Diehl process, is undoubtedly the metallurgical feature of the year. Its advocates have had a tough fight against the all-roasting process, for which the Merton furnaces have decreased the roasting costs to 3s. per ton. The question as between the two processes at first sight seems absolutely simple: Shall one roast all the ore at 3s. a ton; or shall one concentrate out a portion of the ore at so much per ton, roast this at so much, cyanide it at so much, and slime the tailings from the concentrators and bromo-cyanide these? But experience has shown, as the figures above prove, that the cost of the concentrating out and treatment of the rich concentrates, and also of the fine sliming—which consumes ½-h. p. per ton—and bromo-cyanide treatment of the tails apparently still equals, if it does not exceed, the cost of the all-roasting process.

The next move, therefore, of the energetic advocates of the combination process should undoubtedly be to reduce the cost of sliming and bromo-cyaniding by applying this only to that material for which it may be absolutely necessary. Thus, if concentration is not successful in removing all the refractory material from the tailings, it may be due to a considerable extent to the finely divided mineral being carried off in the tailings. This should be recovered in the slimes, therefore, by separation of the sands from the slimes. It may not improbably—at least in certain cases—be found possible to treat these mineral-free sands by the ordinary cyanide percolation process and to use bromo-cyanide for the treatment of the mineral-containing slimes only, and thus the heavy expense of nearly 2s. per ton at present incurred in fine-sliming all the ore not contained in the concentrates would be entirely avoided, as well as the heavy agitation and filter-press costs *on the bulk of the ore,* that is, the sands.

Such a process should probably prove cheaper than the all-roasting process, although it would still be a question whether it could obtain so high an extraction; but there again, although an extraction of over 90 per cent is absolutely necessary with rich ores, when one comes to the treatment of 10-dwt. pulp one has to weigh carefully whether it is worth while obtaining an extra 5 per cent extraction if it costs 2s. a ton or so to do this.

On looking at Kargoorlie practice it is remarkable to note the hold which amalgamation pans have obtained. Their use is practically universal at all the mines which adopted the all-roasting process. The suggestion made, notably by Mr. A. C. Claudet, some six or seven years ago, as to the adoption of amalgamating pans for Kalgoorlie ores, was not received with enthusiasm, but this gentleman certainly has cause for satisfaction at the direction in which recent practice has trended.

Passing on to general details it may be noted that the oil concentration plant, erected at Lake View and tested during the year, does not appear to have been sufficiently successful to cause the adoption of the process by the Lake View company.

With reference to the use of bromo-cyanide, it should be noted that this is now usually made on the spot from imported bromo-salts, in view of the difficulty of getting the steamship companies to carry the actual bromo-cyanide crystals. The *modus operandi* is as follows:

Bromo-salts include potassium bromide and bromate, roughly in the quantities required for the reaction; assuming this to be

$$2KBr + KBrO_3 + 3KCy + 3H_2SO_4 = 3BrCy + 3K_2SO_4 + 3H_2O,$$
$$238 + 167 + 195 + 294 = 318 + 522 + 54$$

The sulphuric acid is made locally, the strength varying from 60 to 90 per cent. Bromo-salts imported from Germany are very impure, but contain the correct mixture to satisfy the above reaction. The charge used at Kalgoorlie to generate 100 lb. of BrCy is: mixed bromo-salts 125 lb., cyanide (100 per cent) 65 lb., sulphuric acid (70 per cent) 147 lb. These salts are agitated in a wood or lead-lined vat of about 200 gal. capacity, securely covered by a lid, through which a revolving paddle or stirrer works; above this is a smaller vat in which is stored the necessary charge of cyanide dissolved in 40 gal. of water. The vat is first three-quarters filled with water, the agitator started, and the sulphuric acid added slowly and carefully; the whole charge is now left to stand until cool, say, one hour, as the great heat generated by the addition of the H_2SO_4 would destroy the bromo-cyanide. When cool the mixed "bromo-salts" are added gradually and the solution of cyanide run in simultaneously with constant stirring; the reaction commences almost immediately, but it is not thoroughly completed until after six hours' continuous agitation.

The end of 1903 found the prospects of the Kalgoorlie field brighter than they have been for many years. The good work done, referred to above; the gradual elimination of the amateur-expert chairman on the boards at home; the extension of the Brownhill shoot, and the good results obtained by the

Great Boulder and other mines in depth, all have tended to infuse fresh vigor into the life of this field.

With reference to further reductions in costs, these must mainly be looked for in the cheaper production of power, the avoidance of power and labor on material for which it may not be necessary, and the gradual displacement of labor as by mechanical excavation in the case of sands.

GRAPHITE.

The production of crystalline graphite in the United States during 1903 amounted to 4,525,700 lb., valued at $164,247, as compared with 4,176,824 lb., valued at $153,147 in the previous year. This variety of graphite is obtained chiefly from Essex county, N. Y., with smaller amounts from Warren county, N. Y., Chester county, Pa., Clay and Coosa counties, Ala., Colfax county, N. M., and Albany county, Wyo. The output of amorphous graphite was 16,591 short tons, valued at $71,384, against 4,739 short tons, valued at $55,964, in 1902. Under this head is included the graphitic anthracite of Rhode Island and the Baraga graphite of Michigan, the latter being really a graphitic schist. In addition amorphous graphite is obtained in Barton county, Ga., Wake county, N. C., Portage county, Wis., Lawrence and Pennington counties, S. D., Ormsby county, Nev., and Sonora county, California. The quantity of artificial graphite manufactured in the United States during 1903 was 2,620,000 lb., valued at $178,670, as compared with 2,358,828 lb., valued at $110,700, in the previous year. In the following table, which shows the annual production, imports and consumption of graphite from 1899 to 1903, inclusive, the crystalline product is given in pounds, amorphous graphite in short tons and the artificial product in pounds.

THE PRODUCTION, IMPORTS, EXPORTS (*a*) AND CONSUMPTION OF GRAPHITE IN THE UNITED STATES.

Year.	Refined Crystalline Graphite.						Amorphous Graphite.		Artificial Graphite.	
	Production.		Imports.		Consumption.		Production.		Production.	
	Pounds.	Value.(*b*)	Pounds.	Value.	Pounds.	Value.	Tons. 2,000 lb.	Value.	Pounds.	Value.
1899.	3,632,608	$145,304	41,586,000	$1,990,649	45,218,608	$2,135,953	1,030	$8.240	405,870	$32,475
1900.	4,103,052	164,122	32,298,560	1,389,117	36,401,612	1,553,239	1,045	8,640	860,750	68,860
1901.	3,967,612	135,914	32,029,760	895,010	36,997,372	1,067,921	809	31,800	2,500,000	119,000
1902.	4,176,824	153,147	40,857,600	1,168,554	45,034,424	1,322,401	4,739	55,964	2,358,828	110,700
1903.	4,525,700	164,247	32,012,000	1,207,700	36,537,700	1,371,947	16,591	71,384	2,620,000	178,670

(*a*) The exports of graphite from the United States amounted to 12 long tons, valued at $834, in 1901, and 3 tons, valued at $365, in 1902. (*b*) Nominal.

The bulk of the supply of crystalline graphite consumed in this country is obtained from the island of Ceylon. A description of the deposits and methods of mining and preparing the product for market will be found later in this chapter. The graphite is imported direct by steamer in packages of 600 lb.

net weight. It is graded and sorted into four qualities, known as lump, chip, dust and flying dust. The lump and chip products are used chiefly in the manufacture of graphite crucibles, lubricants and electrical equipment, while the dust and flying dust are utilized mainly for foundry facings, stove polish, paint, electrotyping, pencils, etc. There is an increasing demand in this country for crystalline graphite, due to the growth of the various industries in which it finds application.

In the manufacture of graphite products the graphite is used in a ground condition. The larger concerns do their own grinding, and a few of the smaller ones purchase the graphite in a ground condition. The principal manufacturers of graphite articles, classified as to products, are given in the subjoined list.

Crucible Manufacturers and Grinders.—Joseph Dixon Crucible Company, Jersey City, N. J.; J. H. Gautier & Company, Jersey City, N. J.; Robt. Taylor Crucible Company, Callowhill Street, Philadelphia, Pa.; Bridgeport Crucible Company, Bridgeport, Conn.; R. B. Seidel & Company, Philadelphia, Pa.; Taunton Crucible Company, Taunton, Mass.; Crucible Steel Company of America, Pittsburg Pa.; Ross-Tacony Crucible Company, Tacony, Pa.; McCollough & Dalzell, Pittsburg, Pa.

Grinders.—Joseph Dixon Crucible Company, Jersey City, N. J.; Philadelphia Graphite Company, Philadelphia, Pa.; United States Graphite Company, East Saginaw, Mich.

Paint Manufacturers.—Joseph Dixon Crucible Company, Jersey City, N. J.; Detroit Graphite Company, Detroit, Mich.; Copper Cliff Mining Company, Chicago, Ill.; Hathaway Graphite Company, L'Anse, Mich.; Wisconsin Graphite Company, Pittsburg, Pa.

Stove Polish Manufacturers.—Joseph Dixon Crucible Company, Jersey City, N. J.; Rising Sun Stove Polish Company, Canton, Conn.; Enameline Stove Polish Company, Passaic, N. J.; Nickel Plate Stove Polish Company, Chicago, Ill.

Foundry Facing Manufacturers.—Joseph Dixon Crucible Company, Jersey City, N. J.; Hill & Griffith, Cincinnati, O.; J. W. Paxson & Company, Philadelphia, Pa.; American Facing Company, New York, N. Y.; T. P. Kelly, New York, N. Y.; Springfield Facing Company, Springfield, Mass.

Grease and Lubricant Manufacturers.—Joseph Dixon Crucible Company, Jersey City, N. J.; Ilsey, Doubleday & Company, New York, N. Y.; J. S. McCormack & Company, Pittsburg, Pa.

Montana.—The deposits of graphite near Dillon, Beaverhead county, which were under exploration in 1902, by the Crystal Graphite Company, have been leased to the Copper Cliff Mining Company, of Chicago, Ill.

New York.—The deposits in Essex and Warren counties continue to supply most of the crystalline graphite produced in this country. The largest operator is the Joseph Dixon Crucible Company, with mines at Graphite, Hague and Ticonderoga. The Ticonderoga Graphite Company, which owns a deposit between Ticonderoga and Schroon, closed down its mill in November, 1903, and the Columbia Graphite Company which began mining early in the present year has since suspended operations.

According to J. F. Kemp the graphite deposits of the Adirondacks may be classed as follows: (1) Pegmatite veins, (2) veinlets of graphite, (3) graphitic quartzites, and (4) crystals of graphite with associated gneissoid strata. In the pegmatites the graphite is coarsely crystalline, but it rarely occurs in sufficient quantities to be workable. It is usually associated with feldspar, pyroxene, hornblende and quartz. The pockety and uncertain nature of the deposits has made all attempts to work them practical failures, except at the old workings of the Dixon company on Chilson hill, Ticonderoga. The graphite veins are usually of small size, following fissures up to an inch in width, and the graphite is crystallized in rather coarse leaves. Considerable fine quartz is mingled with it. The veins so far found are not of sufficient importance to justify mining. The graphitic quartzites form regular stratified members of the sedimentary series, and are the most persistent and reliable of all the deposits. The quartzites are rather feldspathic, and the graphite, associated with some pyrite and other minerals, appears in scales of various fineness interleaving the fragmental minerals of the quartzites. It is never so coarse as in the pegmatites and veins, but its quantity is much greater. In actual amount it varies from 5 to 15 per cent of the rock. These deposits are mined near Hague, Lake George. There are two mills for treating the quartzites, at one of which the rock is crushed by stamps and washed in buddles to a state of comparative purity, while in the second mill the rock is crushed without water, and concentration is effected by Hooper air jigs. The problem of concentration essentially differs from that of metallic ores, since it is a question of saving the light material and rejecting the heavy quartz. The graphitic limestones are coarsely crystalline aggregates of calcite or dolomite with disseminated crystals of pyroxene graphite and other minerals. They have not been utilized thus far as a commercial source of graphite, but they are worthy of serious consideration. The limestone is a soft rock easily crushed, and in separation would free itself from the graphite, although the presence of mica would present difficulties in its concentration.

Pennsylvania.—The plant of the Federal Graphite Company at Chester Springs was destroyed by fire early in 1903, but has been rebuilt. The Philadelphia Graphite Company, operating in the same locality, suspended work for part of the year in order to develop its mine.

Canada.—The output of graphite in Ontario amounted to 4,400 tons of crude product, valued at $20,636. There were three mines in operation: The McConnell, the Allanhurst and the Black Donald. The last-named property, which is owned by the Ontario Graphite Company, was shut down for a part of the year owing to an influx of water into the workings. The Black Donald and McConnell plants turned out 380 tons of refined graphite during 1903.

A new company has been formed in Quebec under the name of the Anglo-

Canadian Graphite Syndicate, Ltd., to take over the property formerly owned by the North American Graphite Company. The new company has secured rights and options on 3,000 acres of land in the county of Ottawa and intends to build during the coming year three concentration mills in this district, besides a finishing mill at Buckingham. The process used in concentration is a new one and is to be tested before active development begins. The quality of the graphite is said to be excellent. The Buckingham company was engaged during a part of the year in prospecting its territory and sinking a new shaft. Some alterations were made to the mill in which about 75 tons of crude ore were treated experimentally. The company intends to resume work the present summer. In the Calumet region the Calumet Mining & Milling Company did some prospecting and shipped a few tons of graphite as an experiment.

WORLD'S PRODUCTION OF GRAPHITE. (IN METRIC TONS.)

Year.	Austria.	Canada.	Ceylon. (*d*)	Germany.	India.	Italy.	Japan.	Mexico.	Sweden.	United States. (*b*)	Totals.
1897.	38,504	396	19,275	3,861	61	5,650	204	907	99	450	69,311
1898.	33,062	1,107	78,509	4,593	22	6,435	346	1,857	50	824	125,006
1899.	31,819	1,105	29,037	5,196	1,548	9,990	55	2,305	(*e*) 535	1,648	80,962
1900.	33,663	1,743	19,168	9,248	1,858	9,720	94	2,561	84	1,799	79,938
1901.	29,992	2,005	22,707	4,435	2,530	10,313	88	1,473	(*f*) 56	1,800	75,399
1902.	29,527	978	25,593	5,023	4,648	9,210	(*c*)	580	63	1,895	77,517

(*a*) Not reported in the government statistics. (*b*) Crystalline graphite. (*c*) Statistics not yet published. (*d*) The figures for 1897, 1899 and 1900 are exports; the enormous production in 1898 as reported in official government publications is not reflected in the exports for that year, which amounted to 24,349 etrmic tons. (*e*) Of this quantity 500 tons were crude products. (*f*) The production of crude graphite during 1901 was 1,727 metric tons, valued at $1,634.

Ceylon.—The output of graphite in 1902, as indicated by the exports, amounted to 25,189 long tons, valued at £701,091. In 1901 the exports were 22,348 long tons, valued at £640,643. Ceylon furnishes about 30 per cent of the world's consumption of high-grade graphite.

The graphite deposits of Ceylon are found in the western and southern provinces and in Sabaragamuwa. The mineral area extends for 95 miles in a north and south direction, with a width of 35 miles at the northern and 43 miles at the southern end. There is one well-defined belt, 18 miles from the coast and 5 miles wide at the northern end, and approaching the coast on the south, where it is 20 miles wide. A second belt is 40 miles in length and has a maximum width of 4 miles. According to George A. Stonier the graphite occurs in veins which traverse a garnetiferous granulite. The veins have a small hade, and the hanging shows evidences of differential movement in its roughly polished and striated surface. In the southern portion of the field the strike is generally north and south, but it varies frequently to east and west in the northern part of the field. No evidence of a main lode or a connected series of lodes has been discovered and the extent of the deposits horizontally is limited. The veins vary from a few inches to 8 ft. in width; a vein 4 inches wide is considered payable. One deposit has been opened to a depth of 720 ft.; but such continuity is uncommon.

In all about 300 mines and quarries are at work, giving employment to 10,000 people. With few exceptions thcy are all workcd by natives and in native fashion. European methods have been tried, but have generally failed. Graphite mining like mica and gem mining is very uncertain, and the native method which involves only small expendIturcs for development and equipment seems best adapted to the eonditions. According to the native procedure the shoot of graphite is followcd from the surfaee to as great a depth as the underground water will permit; in a few cases a shaft is sunk to the water levcl and the vein worked thence to the surfaee. In soft ground a vertieal pit of rectangular section is sunk for about 60 ft. and the mineral is then followed in a series of winzes 50 or 60 ft. deep. Hoisting is done in barrels attached to each end of a rope whieh is passed around a wooden jack-roll. The latter is supplied with iron handles and is worked by six or seven men. The labor employed is almost entirely Sinhalese from Galle. Men earn from 8d. to 1s. per day, and women who work at the surfaee receive from 3d. to 6d. per day.

The graphite as it comes from the mines is conveyed in bags to a dressing shed wherc it is roughly picked and packed in barrels for transport to Colombo or Galle. On arrival at Colombo the barrels are opcned and the material is spread out on a briek or asphalt floor for sorting. The big lumps are placed to one side, and the remainder is thrown onto a scries of stationary screens with holes of $5/8$, $3/8$, $1/4$ and $3/16$ in. in diamcter set at an angle of about 35° from the horizontal. The screened pieces arc taken to sheds where they arc broken by hand and freed from the coarser impurities such as quartz. The graphitc is then plaeed on sacking or boards and rubbed with the addition of watcr. The final polishing is done by hand on a screen placed flat on the ground. The poor material is reduced to powder by wooden mallets or eylindrical beaters, and is hand-picked. At some establishments further eoncentration is cffected by washing in a pit. A circular motion is given to the mineral in a saueer-shaped baskct immersed in the water of thc pit, and the graphite passes into the latter while the hcavier particles remain bchind. The graphite is sun-dried. To separate thc very fine matcrial the better graphite is placcd in a basket, which is rcctangular in section, with the eorners rounded at one cnd and tapering to a line at the other. Whcn the matcrial is thrown into the air the heavier partieles fall back into the baskct, but the fine graphite is blown forward and falls to thc ground. Thc graphite is graded according to sizcs as lump, ordinary, ehips, dust and flying dust,

IRON AND STEEL.

BY FREDERICK HOBART.

The year 1903 marked the culmination and the beginning of the decadence of the period of large consumption and intense activity in iron and steel, which began in 1901. By the middle of the year the approaching decline began to be apparent, though the signs were neglected by most producers, and the break was felt more forcibly when the declining demand had to be recognized. The causes can only be briefly summarized. The first in point of time was the anthracite strike of 1902, with the restraint of business resulting. Others were the exhaustion of purchasing power; the contraction in speculation due to the absorption of floating capital by the various consolidations and combinations of the period of expansion; the determination of certain large operators to realize profits by depressing the speculative markets; and the extension of productive capacity beyond the normal limits of consumption. As in all such periods, these causes of depression are complex and difficult to analyze or separate clearly.

The year marked the end, also, of the period of combination and consolidation. While the United States Steel Corporation added somewhat to its ownership of producing properties, no new combinations of importance were formed; and failures of some enterprises previously started showed that the time for such investments had passed.

Iron Ore.—Production and consumption of iron ore in the United States for the year 1893 in long tons was as follows:

IRON ORE MINED AND CONSUMED IN THE UNITED STATES. (IN TONS OF 2,240 LB.)

District.	1900.	1901.	1902.	1903.
Lake Superior, shipments to furnaces	19,095,393	20,589,237	27,571,121	24,099,550
Southern States, shipments to furnaces	5,100,000	4,767,667	4,850,000	5,889,000
Other States, shipments to furnaces	1,758,000	2,530,575	2,215,000	2,483,000
Total mined in the United States	25,917,393	27,887,479	34,636,121	32,471,550
Add decrease in stocks at Lake Erie docks	....	45,007	....	703,000
Add importations	897,792	966,950	1,165,470	980,440
Total	26,815,185	28,899,436	35,801,591	34,154,990
Increase or decrease in stocks at Lake Erie docks	690,000	....	1,214,591	703,169
Deduct exportation	51,460	64,703	88,445	80,611
Total consumption	26,073,725	28,834,733	34,499,555	34,777,548

The Lake region continues to be the chief source of supply. Allowing for the higher average tenor of its ores, we find that over 75 per cent of the pig iron made in the United States is from Lake ores.

PRODUCTION OF LAKE SUPERIOR IRON ORE BY RANGES, 1900 TO 1903. (LONG TONS.)

Range.	1900.	1901.	1902.	1903.
Marquette range	3,457,522	3,254,680	3,853,010	3,040,245
Menominee range	3,261,221	3,605,449	4,627,524	3,741,284
Gogebic range	2,875,295	2,938,155	3,663,484	2,912,912
Vermilion range	1,655,820	1,786,063	2,084,263	1,674,699
Mesabi range	7,809,535	9,004,890	13,342,840	12,910,455*
Total	19,059,393	20,589,237	27,571,121	24,281,595

*Including 17,913 tons from Iron Ridge.

The following table shows the shipments of iron ore from the Lake Superior region during 1902 and 1903 in long tons:

SHIPMENTS OF IRON ORE FROM LAKE SUPERIOR.

	1902.	1903.	Changes.
Escanaba	5,413,704	4,277,561	D. 1,136,143
Marquette	2,595,010	2,007,346	D. 597,664
Ashland	3,553,919	2,823,119	D. 730,800
Two Harbors	5,605,185	5,120,656	D. 484,529
Gladstone	92,375	85,816	D. 6,559
Superior	4,180,568	3,978,579	D. 201,989
Duluth	5,598,408	5,356,473	D. 241,935
Total by lake	27,039,169	23,649,550	D. 3,389,619
Total all rail	531,952	632,045	I. 100,093
Total shipments	27,571,121	24,281,595	D. 3,289,526

The total decrease as compared with 1902 was 12.3 per cent. As compared with 1901 the increase was 3,692,358 tons, or 17.8 per cent.

In addition to the totals given above, there were 203,419 tons shipped from the Michipicoten range in Canada, of which 170,672 tons were delivered at Lake Erie ports, leaving 32,747 tons sent to Canadian furnaces.

The receipts at Lake Erie ports in detail are reported as follows:

RECEIPTS OF IRON ORE AT LAKE ERIE PORTS.

Ports.	1902.	1903.	Changes.
Toledo	1,037,571	652,305	D. 385,266
Sandusky	165,556	130,532	D. 35,024
Huron	520,646	486,106	D. 34,540
Lorain	1,442,417	990,490	D. 451,927
Cleveland	4,873,318	4,434,160	D. 439,158
Fairport	1,538 744	1 434,342	D. 104,402
Ashtabula	4,796,805	4,242,160	D. 554,645
Conneaut	4,300,301	3,903,937	D. 396,364
Erie	1,717,268	1,257,798	D. 459,470
Buffalo and Tonawanda	2,256,798	2,149,901	D. 106,897
Total	22,649,424	19,681,731	D. 2,967,693

Every port showed some falling off, the larger proportional decreases being at Ashtabula, Erie, Lorain and Toledo.

The stocks at Lake Erie Dec. 1, 1903, showed a decrease of 703,169 tons as compared with 1902.

IRON ORE ON LAKE ERIE DOCKS DEC. 1. (IN TONS OF 2,240 LB.)

Ports.	1902.	1903.	Changes.
Toledo	310,023	106,710	D. 203,313
Sandusky	95,175	95,275	I. 100
Huron	232,764	258,249	I. 485
Lorain	328,304	288,581	D. 39.723
Cleveland	1,500,604	1,337,750	D. 162,854
Fairport	924,236	845,946	D. 78,290
Ashtabula	1,967,136	1,911,911	D. 55,225
Conneaut	673,679	591,364	D. 82,315
Erie	722,966	657,409	D. 65,557
Buffalo	319,367	282,890	D. 36,477
Total	7,074,254	6,371,085	D. 703,169

Statistics collected from the various Lake Erie dock managers show that on May 1, 1904, the stocks of iron ore at Lake Erie ports were greater than on the same date in any year in the history of the trade, the amount being 4,534,103 gross tons. This is not surprising, as furnaces were well supplied when navigation closed, and the curtailment of pig iron production by banking and blowing out resulted in a large decrease in the demand for shipments from docks during the winter. The following table shows the stocks on docks on May 1, 1904, with the amounts on the same docks on Dec. 1, 1903:

STOCKS OF IRON ORES ON LAKE ERIE DOCKS.

Ports.	Dec. 1, 1903.	May 1, 1904.	Changes.
Toledo	106,710	160,216	I. 53,506
Sandusky	95,275	68,863	D. 26,412
Huron	253,249	208,008	D. 45,241
Lorain	288,581	237,404	D. 51,177
Cleveland	1,337,750	968,508	D. 369,242
Fairport	845,946	579,677	D. 266,269
Ashtabula	1,911,911	1,559,028	D. 352,883
Conneaut	591,364	128,018	D. 463,346
Erie	657,409	474,275	D. 183,134
Buffalo	282,890	150,106	D. 132,784
Total	6,371,085	4,534,103	D. 1,836,982

The decrease in stocks represents shipments to furnaces in the winter season. At one port, Toledo, the stocks increased during the closed season; probably by late cargoes, arriving after December 1.

The new Baraboo range in Wisconsin reported no shipments during the year, though some 30,000 tons were mined.

The leading producers of ore in the Lake Superior district were as follows, compared with the season of 1902:

PRINCIPAL PRODUCERS OF IRON ORE.

	1902.	1903.	Changes.
U. S. Steel Corporation	16,025,000	14,355,000	D. 2,570,000
Corrigan, McKinney & Co	2,190,000	1,565,000	D. 635,000
Cleveland Cliffs Iron Co	1,720,000	1,315,000	D. 405,000
Pickands, Mather & Co	1,270,000	1,100,000	D. 170,000
Republic Iron & Steel Co	336,000	493,000	I. 157,000
Penn. Iron Mining Co	792,000	1,000,000	I. 208,000
Jos. Sellwood et al	383,000	831,000	I. 448,000
Jones & Laughlins	442,000	631,000	I. 189.000
International Harvester Co	....	216,000	I. 216,000
Oglebay, Norton & Co.	129,000	240,000	I. 111,000
Ferdinand Schlesinger	309,000	320,000	I. 11,000

There was, of course, a large amount of ore produced by others, but the aggregate was made up by small quantities from each.

In the above table some explanations are necessary. The shipments of the United States Steel Corporation, as given, do not include any part of either Mahoning or Union, though the Corporation owns interests in each. On the other hand, they do include all of the Lake Superior, on the Marquette range and of the Regent, though a 25 per cent interest in each is held by the Cleveland Cliffs Iron Company. The figures for Pickands, Mather & Company do not include half of Cypress, which is owned jointly by them and Joseph Sellwood. Republic Iron & Steel is credited with all of Union, of which it owns but half, and of Clifford, but not with any part of Mahoning, in which it holds a minority interest.

There were fifteen mines on Lake Superior that shipped last year in excess of 500,000 tons each. This is one less than the number which reached that limit the previous year.

Pig Iron.—The total production of pig iron, as reported by the American Iron & Steel Association, in 1903 was 18,009,252 gross tons, against 17,821,307 tons in 1902, 15,878,354 tons in 1901, 13,789,242 tons in 1900, 13,620,703 tons in 1899 and 11,773,934 tons in 1898. The following table gives the half-yearly production of pig iron in the last two years, in gross tons:

	1902.	1903.
First half	8,808,574	9,707,367
Second half	9,012,733	8,301,885
Total	17,821,307	18,009,252

The production of 1903 was 187,945 tons in excess of that of 1902, but the production in the second half of 1903 was 1,405,482 tons less than in the first half. This was a very great decline to occur in six months. The reaction in the iron trade which this decline so pointedly emphasizes really began in the first half of the year, when prices began to break, although the production of pig iron was not adversely affected until after July. It was not, however, until October that production began to decline rapidly, and there was a progressive decline in November and December. Prices of pig iron began to weaken noticeably in April, and from that month until the end of the year there was a steady decline.

The better classification is that made by the purposes for which the iron is intended. Divided in this way, the production for two years was as follows:

PIG IRON PRODUCTION. (IN LONG TONS.)

Kind of Iron.	1901.		1902.		1903.	
	Tons.	%	Tons.	%	Tons.	%
Foundry and forge iron	4,541,250	28.6	5,176,568	29.1	5,785,957	32.1
Bessemer pig	9,546,793	60.4	10,393,168	58.3	9,989,908	55.5
Basic pig	1,448,850	9.1	2,038,590	11.4	2,040,726	11.3
Spiegeleisen and ferromanganese	291,461	1.9	212,981	1.2	192,661	1.1
Totals	15,878,354	100.0	17,821,307	100.0	18,009,252	100.0

The decrease in production in bessemer pig was due to the fact that most of the furnaces which went out of blast in the closing months of the year had been running on that class of iron.

The classification as made by the furnaces is not altogether exact, and some iron reported as foundry and forge is used in making steel.

The production of pig iron, classified according to fuel used, was as follows:

PIG IRON PRODUCTION ACCORDING TO THE FUEL USED. (IN LONG TONS.)

Fuel Used.	1899.	1900.	1901.	1902.	1903.
Bituminous, chiefly coke	11,736,385	11,727,712	13,782,386	16,315,891	15,592,221
Anthracite and coke	1,558,521	1,636,366	1,668,808	1,096,040	} 1,911,347
Anthracite alone	41,031	40,682	43,719	19,207	
Charcoal	284,766	339,874	390,147	378,504	504,757
Charcoal and coke	....	44,608	23,294	11,665	927
Totals	13,620,703	13,789,242	15,878,354	17,821,307	18,009,252

The production of pig iron by States for two years past was as follows:

States.—Long Tons.	1902.	1903.	States.—Long Tons.	1902.	1903.
Pennsylvania	8,117,800	8,211,500	Michigan	155,213	244,709
Ohio	3,631,388	3,287,434	New Jersey	191,380	211,667
Illinois	1,730,220	1,692,375	West Virginia	183,005	199,013
Alabama	1,472,211	1,561,398	Kentucky	110,725	102,441
New York	401,369	552,917	North Carolina and Ga.	32,315	75,602
Virginia	537,216	544,034	Connecticut	12,086	14,501
Tennessee	392,778	418,368	Texas	3,095	11,653
Maryland	303,229	324,570	Massachusetts	3,360	3,265
Wisconsin and Minnesota	273,987	283,516			
Missouri, Colorado and Washington	269,930	270,289	Totals	17,821,307	18,009,252

Nearly all the iron classed as bituminous is made with coke as fuel, very few furnaces in this country using raw coal. Nearly all the anthracite furnaces use some coke mixed with the anthracite coal. A few charcoal furnaces also use some coke; but the quantity of iron reported as made with mixed charcoal and coke in 1903 was only 927 tons. The increase in anthracite iron in 1903 is, of course, due to the fact that in 1902 many anthracite furnaces were forced to use coke alone for part of the year.

The percentage of pig iron output of the several States for the years 1890, 1900, 1902 and 1903 is given below:

States.	1890.	1900.	1902.	1903.
Massachusetts	0.1	0.02	0.02	0.02
Connecticut	0.2	0.08	0.08	0.07
New York	3.6	2.1	2.3	3.0
New Jersey	1.7	1.18	1.1	1.11
Pennsylvania	48.0	46.2	45.5	45.5
Maryland	1.6	2.1	1.7	1.8
Virginia	3.2	3.6	3.0	5.4
North Carolina and Georgia	0.3	0.2	0.18	0.4
Alabama	8.9	8.6	8.3	8.6
Texas	0.1	0.02	0.02	0.06
West Virginia	1.4	1.2	1.0	1.1
Kentucky	0.5	0.5	0.6	0.54
Tennessee	2.9	2.6	2.2	2.3
Ohio	13.5	17.9	20.4	18.2
Indiana	0.2	....	....	....
Illinois	7.6	9.9	9.7	9.4
Michigan	2.5	1.2	0.9	1.3
Wisconsin and Minnesota	2.4	1.3	1.5	1.6
Missouri	1.0	1.1		
Colorado	0.2		1.5	1.5
Oregon and Washington	0.1	......		
Total	100.0	100.0	100.0	100.0

The output of the two chief States—Pennsylvania and Ohio—as shown by percentages, follows:

Districts.	1890.	1900.	1902.	1903.
Pennsylvania:				
Lehigh Valley	7.9	4.0	2.9	0.9
Schuylkill Valley	5.9	3.2	2.9	0.6
Upper Susquehanna Valley	2.0	1.0	0.0	0.0
Lower Susquehanna Valley	5.5	3.9	3.0	3.2
Juniata Valley	2.1	0.9	1.1	
Shenango Valley	6.5	5.8	7.0	7.1
Allegheny County	14.5	22.6	23.9	28.6
Miscellaneous Bituminous	3.4	4.7	4.7	5.1
Charcoal	0.2	....	....	....
Total Pennsylvania	48.0	46.2	45.5	45.5
Ohio:				
Hanging Rock Bituminous	1.0	1.8	1.8	0.7
Mahoning Valley	5.4	7.3	8.1	6.6
Hocking Valley	0.9	0.4	0.2	0.0
Lake Counties	....	3.6	4.8	5.4
Miscellaneous Bituminous	6.0	4.8	5.4	5.5
Hanging Rock Charcoal	0.3	0.1	0.1	....
Total Ohio	13.5	17.9	20.4	18.2

The whole number of furnaces in blast Dec. 31, 1903, was 182, against 320 June 30, 1903; 307 Dec. 31, 1902, and 266 Dec. 31, 1901. The number in blast at the end of 1903 was the smallest at the close of any calendar year since Dec. 31, 1896, when 159 furnaces were in blast.

The production and approximate consumption of pig iron in the United States for two years past are shown in the following table:

ANNUAL CONSUMPTION OF PIG IRON IN THE UNITED STATES, 1899–1903. (IN TONS OF 2,240 LB.)

Pig Iron.	1899.	1900.	1901.	1902.	1903.
Domestic production	13,620,703	13,789,242	15,878,354	17,821,307	18,009,252
Imported	40,393	52,565	62,930	625,383	599,574
Stocks unsold Jan. 1	415,333	68,309	446,020	70,647	49,951
Total supply	14,076,429	13,910,116	16,387,304	18,517,337	18,658,777
Deduct stocks Dec. 1	68,309	446,020	73,647	49,951	591,438
Also exports	228,678	286,687	81,211	27,487	20,381
Approximate consumption	13,779,442	13,177,409	16,232,446	18,439,899	18,046,958

The statement of stock on hand, it should be explained, includes all iron unsold; but it does not include iron made by steel companies and stored for their own use. Should these reserves be included, it is probable that the difference in approximate consumption would be somewhat greater than that shown above. There is no way of ascertaining such reserves exactly; but it is probable that they were greater at the close of 1903 than they were at the opening of the year.

The following table gives the total production of pig iron by grades in the United States for three years past:

PIG IRON PRODUCTION BY GRADES. (IN LONG TONS.)

Grades.	1901.	1902.	1903.
Bessemer and low phosphorus pig iron	9,596,793	10,393,168	9,989,908
Basic pig iron made with mineral fuel	1,548,850	2,038,590	2,040,726
Forge pig iron	639,454	833,093	783,016
Foundry pig iron	3,548,718	3,851,276	4,409,023
Malleable bessemer pig iron	256,532	311,458	473,781
White and mottled and miscellaneous grades	87,969	172,085	120,137
Spiegeleisen	231,822	168,408	156,700
Ferromanganese	59,639	44,573	35,961
Direct castings	8,582	8,656	....
Totals	15,878,354	17,821,307	18,009,252

The production of pig iron in the United States for twelve years past has been as follows:

PRODUCTION OF PIG IRON IN THE UNITED STATES.

Year.	Long Tons.	Year.	Long Tons.
1892	9,157,000	1898	11,773,934
1893	7,124,502	1899	13,620,703
1894	6,657,388	1900	13,789,242
1895	9,446,308	1901	15,878,354
1896	8,623,127	1902	17,821,307
1897	9,652,680	1903	18,009,252

The production in 1892 exceeded that of any previous year. In the twelve years since then the total has nearly doubled.

Six States in 1903 made over half a million tons each. In the order of their output these States were: Pennsylvania, 8,211,500; Ohio, 3,287,434; Illinois, 1,692,375; Alabama, 1,561,398; New York, 552,917; Virginia, 544,034 tons. Pennsylvania alone made 45.5 per cent of all the pig iron.

Classing the production by districts, in the order of their importance, we find that the output was as follows:

	Tons.	Per cent.
Central West	9,568,248	53.1
Seaboard and New England	3,037,606	16.9
Southern States	2,900,856	16.1
Northwest	2,220,600	12.3
West of the Mississippi	281,942	1.6
Total	18,009,252	100.0

In this classification western Pennsylvania and Ohio constitute the Central West; New York, New Jersey, eastern Pennsylvania and Maryland are included with the seaboard States; Illinois, Michigan, Wisconsin and Minnesota are in the Northwest. A further examination of this classification shows that between 70 and 75 per cent of our pig iron was made in districts using Lake Superior ores, either wholly or in part. The proportion of iron made on the seaboard was brought up last year by the large outputs in New York, New Jersey and Maryland. Some New York furnaces use local ores largely, as do those of New Jersey, while the Maryland furnaces run almost entirely on imported ores. The South uses local ores exclusively. The large production in New York last year was, however, chiefly due to the starting of the new furnaces of the Lackawanna Steel Company at Buffalo, which use Lake Superior ores.

The two years past—1902 and 1903—formed a period of exceptional demand when iron brought a high price, and the making was profitable everywhere. They did not alter the tendency to centralize the manufacture of pig iron in the Central West and the Northwest—the region where Lake ores and cheap coke can be had; and in the South, where ores and fuel are close together. In the East and on the seaboard, in the long run, furnaces will prosper only under exceptional conditions; as at Port Henry, on Lake Champlain, and at Netcong, in New Jersey, where special ore supplies are available; or at the Maryland Steel Company's plant, near Baltimore, where Cuban ores are landed cheaply and a special market exists. The only hope for Eastern furnaces seems to be in the establishment of their own coke plants; in the saving of by-products from the coke, the slag and the like; in the utilization of waste gases, and in other economies to which the advance of metallurgical science may point the way.

Steel.—The total production of steel in the United States for the last five years follows:

PRODUCTION OF STEEL IN THE UNITED STATES. (IN TONS OF 2,240 LB.)

Kinds.	1899.	1900.	1901.	1902.	1903.
Bessemer	7,586,354	6,684,770	8,713,302	9,138,363	8,577,228
Open-hearth	2,947,316	3,402,552	4,656,309	5,687,729	5,837,789
Crucible	128,500	131,250	103,984	121,158	112,238
Total tons	10,662,170	10,218,572	13,473,595	14,947,250	14,527,255
Total metric tons	10,832,767	10,382,069	13,689,945	15,186,406	14,756,691

The following table gives the production of bessemer steel ingots and castings in the last six years. Of the production last year 17,099 tons were steel castings, against 12,548 tons in 1902:

PRODUCTION OF BESSEMER STEEL.

Year.	Long Tons.	Year.	Long Tons.
1898	6,609,017	1901	8,713,302
1899	7,586,354	1902	9,138,363
1900	6,684,770	1903	8,577,228

Below is given by States the production of bessemer ingots and castings in the last two years:

	1902.	1903.	Changes.
Pennsylvania	4,209,326	3,909,436	D. 299,890
Ohio	2,528,802	2,330,134	D. 198,668
Illinois	1,443,614	1,351,968	D. 91,646
Other States	956,621	985,690	I. 29,069
Total	9,138,363	8,577,228	D. 561,135

There were no Clapp-Griffiths works in operation in 1903 and only two Robert-Bessemer plants were active. Seven Tropenas plants were at work, as compared with five in 1902. In addition, one plant made steel by the Bookwalter process and one plant on the Pacific coast made a small quantity of steel in a special surface-blown converter. One plant also made steel by the Evans-Wills process. All these active works produced steel castings only.

The production of bessemer steel rails in the United States in 1903 was 2,873,228 tons, against 2,947,933 tons in 1902; 2,874,639 tons in 1901; 2,385,682 tons in 1900; 2,272,700 tons in 1899; and 1,981,241 tons in 1898. The rails made in 1903 were divided according to section, as follows: Under 45 lb. to the yard, 177,661 tons; over 45 lb., and less than 85 lb., 1,498,678; over 85 lb., 1,196,889. There was a large increase in the proportion of heavy rails, over 85 lb. Such rails were 21.9 per cent of the total in 1902, but 41.7 per cent in 1903.

The total production of open-hearth steel ingots, including direct castings, by the open-hearth furnaces was as follows, in long tons:

	1902.		1903.		Changes.
	Tons.	Per Cent.	Tons.	Per Cent.	Tons.
Acid	1,191,196	20.9	1,095,876	18.8	D. 95,320
Basic	4,496,533	79.1	4,741,913	81.2	I. 245,380
Total	5,687,729	100.0	5,837,789	100.0	I. 150,060

This shows that, while there was a decrease of 8 per cent in steel made by the acid process, the output of basic steel gained 5.5 per cent, the result being an increase of 2.6 per cent in the total output. This again emphasizes the advance in basic steel making. The basic furnaces now furnish four-fifths of our open-hearth steel, and nearly one-third of our entire production.

The open-hearth steel made in 1903 was produced by 111 works in 17 States—Massachusetts, Connecticut, Rhode Island, New York, New Jersey, Pennsylvania, Delaware, Maryland, Tennessee, Alabama, Ohio, Indiana, Illinois, Wisconsin, Missouri, Colorado and California. Ninety-eight works in 16 States made open-hearth steel in 1902. The States which have open-hearth furnaces, but which did not produce open-hearth steel in 1903, were West Virginia and Kentucky.

In the following table the production by States of both acid and basic open-hearth steel ingots and castings in 1903 is given in long tons:

	Basic.	Acid.	Total.
New England	105,778	63,431	169,209
New York and New Jersey	71,537	33,061	104,598
Pennsylvania	3,557,493	884,865	4,442,358
Ohio	308,575	60,674	369,249
Illinois	390,513	32,406	422,919
Other States	308,017	21,439	329,456
Total	4,741,913	1,095,876	5,837,789

The following table gives the production of open-hearth steel castings, direct from the furnace, by the acid and basic process in 1903 by States, in long tons:

	Basic.	Acid.	Total.
New England, New York and New Jersey	5,311	30,783	36,094
Pennsylvania	14,483	150,749	165,232
Ohio, Illinois, and other States	115,085	68,398	183,483
Total	134,879	249,930	384,809

In addition to the States enumerated in the table, Massachusetts, Connecticut, Tennessee, Alabama, Indiana, Wisconsin, Missouri and California made open-hearth steel castings in 1903.

The growth of the basic process is further shown by the following table, which gives the entire output of steel, in 1903, classified as acid and basic. The output of bessemer, or converter, steel is entirely by the acid process, the basic converter having been always a negligible factor in our practice. The figures below are also in long tons:

	Acid.		Basic.	
	Tons.	Per Cent.	Tons.	Per Cent.
Bessemer	8,577,228	59.0	....	....
Open-hearth	1,095,876	7.5	4,741,913	32.6
Crucible, etc	112,238	0.9	....	....
Total	9,785,342	67.4	4,741,913	32.6
Totals, 1902	10,450,717	69.9	4,496,533	30.1

Over 40 per cent of the total was open-hearth metal, and the loss from 1902 was entirely in converter steel.

The production of structural steel shapes reached a total of 1,095,813 tons. Bessemer steel continues to be used largely for rails and bars, though the making of rails from basic open-hearth metal has been begun in Alabama. For structural steel, and very largely for plates, the open-hearth steel is now preferred, and for castings its use is very general. The open-hearth furnace is steadily gaining, and there is little doubt that, in a few years, it will displace the converter as our chief steel producer.

The total production of all kinds of iron and steel rolled into finished forms in the United States from 1899 to 1903 is given below, in long tons:

Year.	Iron and Steel Rails.	Bars, Hoops, Skelp and Shapes.	Wire-Rods.	Plates and Sheets, Except Nail Plate.	Cut Nails. Gross Tons.	Total Gross Tons.
1899	2,272,700	4,966,801	1,036,398	1,903,505	85,015	10,294,419
1900	2,385,672	4,390,697	846,291	1,794,528	70,245	6,487,443
1901	2,874,639	5,685,479	1,365,934	2,254,425	68,850	12,349,327
1902	2,947,933	6,583,545	1,574,293	2,665,409	72,936	13,944,116
1903	2,992,477	6,047,998	1,503,455	2.599,665	64,102	13,207,697

United States Steel Corporation.—From the official report of this company, covering the year 1903, the following facts are obtained:

The stocks and bonds outstanding at the close of the year were:

Common stock	$508,302,500
Preferred stock	360,281,100
Stocks of subsidiary companies outstanding	109,115
Bonds and debentures, U. S. Steel Co	468,319,000
Bonds of subsidiary companies	99,819,535
Mortgage and purchase money obligations	5,882,864
Total stocks and bonds	$1,442,714,114

The expenditures by all subsidiary companies during the year for construction and additions to the property, less credits for property sold, equaled the sum of $31,042,136. Included in this total, however, are outlays amounting to $8,421,189 made on account of the furnaces, steel works, and mills of the Union Steel Company, and for the development of that company's coal, coke and railroad properties. The balance of the expenditures, $22,620,947, represents outlays for additions and extensions to the various properties of other subsidiary companies. These expenditures comprehend only actual additions and extensions to the plants and properties.

The total inventories of all properties made Dec. 31, 1903, amounted to $107,976,523, in comparison with an aggregate of $104,390,844 on Dec. 31, 1902, an increase of $3,585,679. This increase is more than accounted for in the item of ore alone, which shows an increase over last year of $7,946,049, or 23 per cent, in inventory valuation, and an increase of 31 per cent in quantity on hand. This increase in the quantity of ore on hand is due partly to the fact that inventories this year include the stocks of the Union Steel Company (not embraced last year), and partly owing to the diminution of ore conversions during the last quarter. As explained in previous reports, it is necessary (owing to the close of navigation on the Great Lakes during the winter) to mine and ship to furnaces and to storage docks during the summer and fall, sufficient quantities of ore to insure a supply for the furnaces up to the early summer of the succeeding year. The inventories of commodities other than ore are also increased by reason of including the stocks of the Union Steel Company, to which reference is made above.

Inventory valuations are conservative. They were taken on the basis of actual purchase or production cost of materials to respective companies holding the same, unless (as happened in some instances) such cost was above the market value on Dec. 31, 1903, in which cases the market price was used. The aggregate inventory valuation of all raw, partly finished and finished materials produced within the organization is very largely below the market prices on Dec. 31, 1903. No profit is taken up by any one subsidiary company on materials and products of its own production until the same have been shipped to customers.

The number of stockholders of the United States Steel Corporation on the respective dates shown below was as follows:

	1903.	1904.
Preferred (Feb., 1904 and 1903)	31,799	42,720
Common (Dec., 1903 and 1902)	26,830	37,237
Totals	58,629	79,957

This shows an increase of 21,328 in the number of shareholders.

The offer to the employees of this corporation and of the subsidiary companies to subscribe for the preferred stock of this corporation was renewed at the end of the year 1903 for the succeeding year, and resulted in a subscription of 10,248 employees for 32,519 shares.

The statement of general receipts and expenses may be given as follows:

Gross sales and earnings	$536,572,876
Miscellaneous receipts	1,720,043
Proportion of earnings of properties separately operated	3,548,550
Total receipts	$541,841,466
Manufacturing and producing costs	$409,268,599
General and selling expenses	16,847,853
Interest of mortgages and current interest	6,553,862
Total expenses	$432,670,314
Net earnings	$109,171,152

The net earnings shown above are the basis of the income account, which is as follows:

Net earnings, as above	109,171,152
Sinking funds	$1,598,013
Depreciation funds	4,599,822
Replacement fund	9,297,531
Special improvement fund	10,000,000
Interest account	22,880,296
Depreciation in inventory values	5,378,838
Total charges	$53,754,500
Balance, profit	$55,416,652

The products for the year are stated as follows, in tons:

	1902.	1903.
Iron Ore Mined—		
From Marquette range	1,487,370	1,412,402
From Menominee range	2,675,754	2,106,443
From Gogebic range	2,064,492	1,867,856
From Vermilion range	2,057,537	1,918,584
From Mesabi range	7,778,026	8,058,070
Total	16,063,179	15,363,355
Coke manufactured	9,521,567	8,658,391
Coal mined, not including that used in making coke	709,367	1,120,733
Limestone quarried	1,313,120	1,268,930
Blast furnace products—		
Pig iron	7,802,812	7,123,053
Spiegel	128,265	121,779
Ferromanganese and silicon	44,453	34,409
Total	7,975,530	7,279,241
Steel ingot production—		
Bessemer ingots	6,759,210	6,191,660
Open-hearth ingots	2,984,708	2,976,300
Total	9,743,918	9,167,960

	1902.	1903.
Rolled and other finished products for sale—		
Steel rails	1,920,786	1,934,315
Blooms, billets, slabs, sheet and tin plate bars	782,637	493,292
Plates	649,541	519,713
Merchant steel, skelp, shapes, hoops, bands, etc.	1,254,560	997,595
Tubing and pipe	744,062	795,821
Rods	109,330	101,699
Wire and products of wire	1,122,809	1,126,605
Sheets—black, galvanized and tin plate	783,576	855,215
Finished structural work	481,029	469,692
Angle and splice bars and joints	139,954	138,709
Spikes, bolts, nuts, rivets	42,984	53,259
Axles	136,787	119,716
Sundry iron and steel products	29,177	30,059
Total finished products	8,197,232	7,635,690
Other products—		
Spelter	23,982	23,841
Copperas	14,224	15,407
Cement, bbls	486,357	644,286

From the profits there were paid dividends of 7 per cent on preferred and 2.5 per cent on common stock, amounting in all to $43,111,736, and leaving an undivided balance of $12,304,916.

The expenditures made by all properties during the year for maintenance, renewals and extraordinary replacements equaled the sum of $34,785,191. This entire amount has been charged to current operations. The physical condition of the properties has been not only fully maintained, but largely improved and strengthened by these extensive outlays, both in respect to increasing the productive and operating capacity and reducing operating costs. The expenditures for extraordinary replacements in 1903 exceeded those for 1902 by $5,012,985.

The average number of employees in the service of all companies during the fiscal year 1903, in comparison with the fiscal year 1902, was as follows:

Employees of	1902.	1903.
Manufacturing properties	125,326	123,397
Coal and coke properties	16,519	17,873
Iron ore mining properties	13,465	13,768
Transportation properties	11,160	11,033
Miscellaneous properties	1,657	1,638
Total	168,127	167,709

The total amounts paid in wages and salaries were $120,528,343 in 1902, and $120,763,896 in 1903.

The report says: "In accordance with the policy pursued by the Corporation since its organization, substantial progress was made during the fiscal year last ended in the consolidation of its subsidiary interests. On April 1, 1903, The Carnegie Company, American Steel Hoop Company and National Steel Company were merged under the charter of the last named, the name being subsequently changed to Carnegie Steel Company. On the same date a merger was effected of the H. C. Frick Coke Company, McClure Coke Company, United Coal & Coke Company, Southwest Connellsville Coke Company, American Coke Company and Continental Coke Company, the new company retaining the name of H. C. Frick Coke Company. Thus two corporate operating organizations replaced nine previously existing. On Dec. 31, 1903, the interests of the American Tin Plate Company and the American Sheet Steel Company were united through the purchase by the latter of the property of the former. The name of the American Sheet Steel Company has been changed to American Sheet & Tin Plate Company.

"The Union Steel Company properties acquired as of Dec. 1, 1902, have been leased to various other subsidiary companies operating similar lines of manufacture. This entails no additional administrative expense to the lessees. The entire net revenue from the operations accrues to the Union Steel Company.

"On Nov. 1, 1903, the United States Steel Products Export Company, whose stock is held by the Federal Steel Company, made arrangements to act as selling agent for all subsidiary companies. The result has been an increase in the export trade.

"During the year general trade conditions materially changed, and the business of the subsidiary companies, in common with the business of all others, suffered by reason of the falling off in orders. The effect upon profits has been shown accurately from time to time in the published statements. So soon as it became evident to the directors that there was likely to be a large diminution in the net profits to be realized by way of dividends from subsidiary companies, it was deemed wise and prudent to reduce the dividend on the common stock of the Corporation, and later for the same reason to suspend payment of dividends on this stock. In the determination of these questions the directors gave careful consideration to all the facts and circumstances bearing upon the subject and due regard to the relative rights and claims of all who are interested in the continuous and permanent success of the Corporation and the advancement of its business.

"On Dec. 31, 1903, the tonnage of unfilled orders on the books was 3,215,123 tons of all kinds of manufactured products, in comparison with a tonnage of 5,347,253 at corresponding date in the previous year."

United States Exports and Imports.—Export business during the year was naturally affected by the large demand and the high prices in the domestic market. Toward the end of the year, when trade began to fall off, a movement was begun to export material to foreign markets, but any expansion of export trade will be shown in the returns of 1904. The exports of iron and steel, including machinery, from the United States for the year were valued at $99,036,697. Most of this business was on the lines in which we have had established trade, the exports of pig iron, steel billets and wire-bars, and of rails, which made an important figure three years ago, having fallen almost to nothing.

The following table, compiled from the reports of the Bureau of Statistics of the Treasury Department, gives the exports of leading articles of iron and steel in the calendar years 1900, 1901, 1902 and 1903:

EXPORTS OF IRON AND STEEL, 1900–1903. (IN LONG TONS.)

Article.	1900.	1901.	1902.	1903.
Pig iron	286,687	81,211	27,487	20,381
Scrap and old, for remanufacture.	49,328	14,199	9,411	8,034
Bar iron.	13,299	17,708	22,249	19,380
Band, hoop, or scroll iron and steel	2,976	1,561	1,674	2,141
Bars or rods of steel not wire-rods	81,366	27,397	9,300	17,802
Steel wire-rods	10,652	8,165	24,613	22,449
Billets, ingots, and blooms	107,385	28,614	2,409	5,445
Cut nails and spikes	11,163	9,302	7,170	8,890
Wire nails	27,404	18,773	26,580	31,498
All other nails, including tacks	1,812	1,806	2,244	2,321
Iron plates and sheets	9,331	6,900	3,434	4,782
Steel plates and sheets.	45,534	23,923	14,866	13,242
Iron rails	5,374	901	211	181
Steel rails.	356,245	318,055	67,455	30,656
Structural iron and steel	67,714	54,005	53,859	30,641
Wire.	78,014	88,238	97,843	108,502
Total	1,154,284	700,857	370,805	326,345

The imports of leading articles of iron and steel for the years 1900 to 1903, on the next page, are from the official figures of the Bureau of Statistics of the Treasury Department.

IMPORTS OF IRON AND STEEL, 1900–1903. (IN LONG TONS.)

Article.	1900.	1901.	1902.	1903.
Pig iron, spiegeleisen, and ferromanganese	52,565	62,930	625,383	599,974
Scrap iron and scrap steel	34,431	20,130	109,510	82,941
Bar iron	19,685	20,792	28,844	43,270
Iron and steel rails	1,448	1,905	63,522	95,555
Hoop, band, or scroll iron and steel	165	2,974	3,362	1,525
Steel ingots, billets, structural steel, etc	12,709	8,163	289,318	261,559
Sheet, plate, and taggers' iron or steel	5,143	5,621	7,156	11,691
Tin plates	60,386	77,395	60,115	47,360
Wire-rods, iron and steel	21,092	16,804	21,382	20,835
Wire, and articles made from wire	1,848	4,129	3,468	5,036
Anvils	223	251	203	249
Chains	260	198	576	369
Total	209,955	221,292	1,212,839	1,170,364

These imports were almost wholly in the last half of 1902 and the first half of 1903. In the later months of 1903 they fell to comparatively low figures. Thus, if we take as typical the imports of pig iron and of steel ingots, billets and bars, we find that in January, 1902, they were 7,833 and 5,312 tons, respectively; while in November of that year they were 100,400 and 41,077 tons, respectively. In January, 1903, we imported 110,679 tons of pig iron and 38,691 tons of crude steel, while in November the imports were only 18,765 tons of pig iron and 6,580 tons of steel.

Iron and Steel Markets.

The unprecedented demand and the high prices with which the year opened, and which lasted well through the first half, began to show a falling off soon after the middle of the year. Labor troubles, especially in the building trades, gave the first warning, and this was followed by other symptoms which soon showed to experienced observers that the boom period was approaching its end. The diminution in the number of contracts offered, coupled with demands for concessions in prices, followed rapidly, and the year closed with many plants shut down, and with others working with reduced energy.

The general course of trade is shown by the local markets following, of which Pittsburg is naturally of the first importance.

(By S. F. Luty.) The iron and steel trade in 1903 was the reverse of the preceding two years, and like that of 1900, in that there was a gradual decline instead of advance in prices of several important lines from the opening to the close. The greatest reductions were in pig iron, and in steel billets and steel bars. Bessemer pig iron sold in January at $22.35, while in December $14.50 was quoted, and the demand was extremely light. Sales of bessemer billets at the opening of the year were at prices around $30 and $31; and before the year ended $23 was the uniform price for both bessemer and open-hearth billets. In 1900 bessemer pig sold in January at $25 and in December at about $14, while bessemer billets dropped from $35 to $20. The year cannot be regarded as a satisfactory one, there being a number of discouraging features. Furnaces had great difficulty in the opening months in securing coke, on account of the railroad blockade, which continued from the previous fall. Many furnaces were banked for days at a time, and to get coke unusual prices, ranging from $5 to $8 at the oven, were paid. This condition of affairs continued until early spring, when the blockade was removed.

Then came troubles in the building trades, which not only checked buying of structural material, but delayed specifications on contracts. All the mills were crowded with orders for structural material early in the year, and the outlook for a heavy business throughout the year was very bright. In March a strike was ordered against the American Bridge Company by the International Association of Bridge & Structural Iron Workers, and a number of important contracts were tied up in this district for six weeks. The erection of a large number of buildings that had been contemplated was deferred on account of the uncertainty due to the extravagant demands for advances in wages by labor organizations of the various trades.

There was no change in the prices of steel rails, plates and shapes. The rates of $28 for rails and 1.60c. for shapes and plates, which were established in April, 1901, continued throughout 1903. There was no great fluctuation in other leading lines outside of a heavy drop in merchant steel bars. The price of 1.60c. for steel bars, which became effective in April, 1902, continued until November last, when it was cut to 1.30c., or $6 a ton. The price of nails remained around $2 a keg all the year. Wire nails sold in January and December at $1.90, but during the ten intervening months the price was $2. Cut nails sold in the first quarter at $2.10, and were advanced to $2.15, dropping to $1.90 in November. Sheets were weak throughout the year. Black sheets, No. 28 gauge, were quoted at 2.75c. for the first half, but it is known that concessions were made on desirable orders. The American Sheet Steel Company was getting most of the business, as independents had difficulty in meeting the low prices, owing to the high price of sheet bars and the advantage the big interest possessed in the matter of unlimited production at its non-union plants. In November, the big sheet company announced a reduction in prices, making the rate of No. 28 gauge black sheets 2.40c. and 3.40c. for galvanized. Some concessions, it is reported, were made on these low rates. There were no material reductions or changes in the price of ferromanganese. It was quoted at about $50 until late in the year, when it dropped to $48, and sold in December at $47. On January 2 an advance of $1 a ton in the price of plain wire was announced, and a further advance of $2 was ordered on February 23, which made the price 1.90c. base. These advances, however, did not indicate a stronger market, but were due to the removal of competition through the absorption by the United States Steel Corporation of the Union-Sharon wire plants. The deal was concluded late in November, 1902, and during that year the price of wire products had been cut $7 a ton.

There was a good demand for tin-plate during the first half of the year, and on March 10, the American Tin Plate Company advanced the price from $3.60 to $3.80 a box. The company had captured a large amount of rebate trade, for which business the workers had made a concession in wages, paying 3 per cent of their earnings into a fund from which the company was paid 25 per cent of the labor cost on all plate going into the rebate or export trade. The collection of 3 per cent of the workers' wages for this fund was stopped on June 1, as there was enough domestic trade to keep the mills busy. The independents, during the busy canning season, obtained premiums of 10 and 15c. a box above the fixed price. Trade became dull at the close of the canning season, and on October 1 the collection of 3 per cent of the workers' wages for the rebate fund was resumed, and the American Tin Plate Company again went after the foreign business. In November the price was reduced to $3.60 a box, and a large number of the independent producers were forced out of the market.

The outlook for pig iron at the opening of the year was remarkably good, there being every indication that firm prices would prevail and that production would exceed all former years. This belief was not dispelled until after the first quarter, the lack of new business being attributed to hesitation of buyers, owing to the inability of furnaces to operate steadily, because of the freight congestion and the shortage of coke. The United States Steel Corporation did not come into the market for a large tonnage, as had been expected. It had an option on 150,000 tons of bessemer iron for delivery during the second half at $20.50, Valley furnaces, or $21.35, Pittsburg. As the average price for January was just $1 higher to the general trade, it was believed pig iron would be held at a profitable figure throughout the year. On March 25, however, the Corporation allowed its option to lapse, and on April 1 southern producers announced a reduction. Just before these announcements were made, independent steel interests contracted for bessemer pig iron aggregating 75,000 tons at prices ranging from $20.85 to $21.50, Pittsburg. There was plenty of coke in April, and the furnaces were operated to their full capacity; Clairton furnace No. 1 was blown in on April 21. In May, sales of bessemer iron to independents aggregated 60,000 tons, at prices ranging from $20.75 to $21, Pittsburg. On May 26 the United States Steel Corporation came into the market, buying 100,000 tons at $19, Valley, for June delivery, and $18.50 for delivery in the third quarter. The Bessemer Furnace Association got 43,000 tons of this order; W. P. Snyder & Company, 40,000 tons, and Rogers, Brown & Company, 17,000 tons. This contract had the effect of stimulating the market, but there was no heavy buying, and prices continued to drop. Small orders only were placed, and all were for immediate shipment. Clairton furnace No. 2 was blown in on June 23. The production of pig iron this month was heavy, all the Valley furnaces being in operation, but the product was not sold, a great deal going into stock. Prices, however, were fairly well maintained until about the middle of the third quarter, when there was considerable shading, but the extent was never made public. The average price quoted for August, at which a number of important sales were made, was $17.85, but it is certain that a large tonnage was sold at a less figure. On September 29 a meeting of the furnace interests of the Central West was held here, and a movement was started to restrict production in order to maintain prices. It was decided to curtail production from October 1 to January 1 by 25 per cent, and all but about 17 per cent of the producing interests entered into the agreement. Before December 1 the lack of business had the effect of curtailing production more than 50 per cent, and prices declined almost to the low point reached in the last quarter of 1900.

An important deal was supposed to have been closed in July. The announcement was made that the United States Steel Corporation had taken over a half interest in the Clairton Steel Company, a subsidiary concern of the Crucible Steel Company of America. The amount of the purchase said to have been agreed upon was $6,000,000. Early in October W. P. Snyder, president of the Clairton Company, went to New York to obtain a settlement. Instead of receiving the cash expected, he was told that "obstacles have arisen which prevent the plans being carried out." This announcement had a depressing effect on the stock market and on conditions in general. The failure to complete the deal necessitated a reorganization of the Crucible Steel Company of America. More than $2,000,000 was raised to provide working capital for the Clairton plant, and William G. Park was made chairman and given full control. The sale of the Clairton property was finally completed in April, 1904.

The United States Steel Corporation began to retrench, and operating expenses were greatly curtailed toward the last of the year. Early in 1903 the American Steel Hoop Company and the National Steel Company were absorbed by the Carnegie Steel Company and put under the direct control of President W. E. Corey. In August, Charles M. Schwab resigned the presidency of the United States Steel Corporation, and Mr. Corey took his place, A. C. Dinkey succeeding him as president of the Carnegie Steel Company. The consolidation proved so successful that others were considered, and in November plans were made for combining the American Tin Plate Company and the American Sheet Steel Company, to become effective on the first of the year. Wages were reduced late in the year at a number of the non-union works, and a general plan for cutting down expenses on the first of the year was outlined.

The H. C. Frick Coke Company, a part of the big corporation, was not in the coke market until late in October, as the entire product was used at the plants of the corporation. Furnace coke sold during the first half at $3 a ton, and foundry coke was $1 and $1.50 higher. Prices began to drop in the last half, and in December furnace coke sold as low as $1.50 and foundry at from $2.25 to $2.50. The independent coke operators got together on October

24 and formed a pool, which was composed of twenty-three interests. The object was to maintain prices, but the plan failed. A general meeting of coke interests was held later to discuss some plan for protecting the industry. The matter was put in the hands of a committee.

There was a heavy demand for common iron bars at the opening of the year, and prices were advanced to 1.80c. The puddlers and finishers in the mills of the country that are operated under the wage scale of the Amalgamated Association of Iron, Steel & Tin Workers, were greatly benefited, as their pay is based on the selling price of bar iron. The puddling rate in January and until July 1 was \$6.12½ a ton, when it was advanced to \$6.25 a ton, being the highest rate paid in twenty years. Prices began to decline, and the puddling rate went down to \$6 on September 1 and to \$5.75 on November 1. During the last two months of the year bar iron sold as low as 1.30c.

The capacity of the sheet mills of the country is in excess of the consumption, and as a result the independent manufacturers who operate under the Amalgamated Association scale, which limits production, were unable to get much business, as they could not compete with the non-union plants where there was no limit. The Amalgamated Association was asked to assist by removing the limit. On August 31 a special convention of representatives of the sheet mill lodges was held in Pittsburg. After discussing the matter for two days it was decided to make no change. Prices of sheets continued to decline, and No. 28 gauge black sheets were quoted as low as 2.40c. Another request was made by the independent sheet manufacturers and a second special convention was held on December 8. It continued in session a week. This convention practically removed the limit by increasing it from 135 to 150 pairs a turn. The base of the sheet scale, which has been 3c. for Nos. 26, 27 and 28 gauges was reduced to 2.50c., which means a cut of 10 per cent in wages. Under the Amalgamated scale the pay advances 2 per cent with every 0.01c. increase above the base and declines 2 per cent with every drop of 0.01c. in price to the base of the scale.

AVERAGE PRICES PER TON OF IRON AND STEEL IN PITTSBURG DURING 1903.

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Bessemer pig.	\$22.35	\$21.85	\$21.85	\$21.35	\$20.00	\$19.85	\$19.00	\$17.85	\$17.00	\$16.00	\$15.10	\$14.50
Foundry No. 2	23.00	22.00	21.50	21.50	21.00	20.50	18.75	17.50	16.00	15.25	14.50	14.25
Gray forge.	21.00	21.00	20.75	20.25	19.75	19.25	17.50	16.00	15.25	14.25	13.25	13.00
Bessemer steel billet	30.50	30.00	30.50	31.00	31.00	30.00	27.00	27.00	27.00	27.00	23.00	23.00
Sheets No. 28	2.75	2.75	2.75	2.75	2.75	2.75	2.70	2.70	2.70	2.70	2.40	2.40
Tank plate	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
Steel bars	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.30	1.30
Steel rails	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00
Wire nails	1.90	1.90	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	1.90	1.90
Cut nails	2.10	2.10	2.10	2.15	2.15	2.15	2.15	2.15	2.15	2.15	1.90	1.90
Ferromanganese domestic	51.00	50.00	50.00	50.00	50.00	50.00	50.00	49.00	48.00	48.00	48.00	47.00

Alabama (By L. W. Friedman).—The year 1903 closed with conditions precisely the opposite of those prevailing when the year opened. In January prices were high for pig iron and other metals. The demand was not at its best, though good. A couple of months later showed the market still strong as to quotations, but consumers were inclined to hold off in their buying until some concessions should be made. Furnace men were able to hold up prices for week after week, but before the middle of summer surplus iron began to accumulate in thc yards. The close of the year found the market turning from a dull spell, with a very active demand, and prices only a little advanced over the lowest quotations in the history of iron-making in Alabama, except for the period 1894 to 1897. January saw No. 2 foundry quoted around \$17.50, \$18.50 and \$19 per ton. The close of the year found No. 2 foundry firm at \$9.50, but much had been sold at \$9, and even lower.

There was a good increase in production over the preceding year. For eight months the furnaces worked steadily. A slight curtailment commenced when the demand fell off, and the manufacturers thereupon asked the railroads to concede 50c. per ton in freight rates, so that iron could be sold and shipped in a declining market. It was not until October, however, that resolutions were adopted and, to a certain extent, carried out to reduce the production of pig iron in the Southern territory, which resulted in curtailing the output about 33 1-3 per cent. But thc larger furnaces did not reduce their production in proportion, as they were in position to make iron cheaply, and at the close of the year they were turning out almost as much iron as at the start.

During 1903 work was started on three or four new blast furnaces. Several furnaces were repaired, practically rebuilt, and equipped with new and modern machinery. Two large new furnaces went into operation during the year—one at Gadsden, belonging to the Alabama Consolidated Coal & Iron Company, and the other at Holton, in Tuscaloosa county, belonging to the Central Coal & Iron Company. The Tennessee Coal, Iron & Railroad Company started work on a new furnace at Ensley, the Alabama Steel & Wire Company on one at Gadsden, the Woodward Iron Company one at Woodward, and the Lookout Mountain Iron Company one at Battelle, in DeKalb county.

Several furnaces were thoroughly repaired, notably one of the Sloss-Sheffield Steel & Iron Company's furnaccs in the Sheffield district; one of the Republic Iron & Steel Company's Thomas furnaces; the Tennessee Coal, Iron & Railroad Company's furnace at Bessemer, and onc at Ensley, and the Woodward Iron Company's at Woodward. The steel plant at Ensley, belonging to the Tennessee Coal, Iron & Railway Company, was operated steadily for nine months in the year, and fairly well during the tenth month. In November there was a shut down, and the last two months the output amounted practically to nothing. At the steel rod, wire and nail mills no work was done at all this year. The steel plow works at Ensley changed hands during the year, and were improved and put in operation on a better scale than ever before.

Ohio (By G. W. Cushing).—The iron and steel situation in this territory during the past year was a natural evolution from conditions which existed when the year opened. It afforded also a study into the Steel Corporation and its influences. The year opened with high-priced pig iron being used by all foundries and mills, and with contracts running through the first half of those prices. Mills like those of the Steel Corporation, which could make their own pig iron and save the profit on it, were able to hold to conservative prices for the finished product, but the smaller mills, being forced to pay high prices for pig iron or billets, were compelled to ask higher prices for their finished product. This resulted in a list of premium prices for finished products, which, before the year was over, destroyed the equilibrium of the market, sending the prices first rapidly up the scale and then down toward the close. The reduction was even more radical than the advance.

Pig Iron.—In the pig iron trade the evidences of a possible decline in the trade began very early. The latter part of the year 1902 was given over to violent efforts on the part of the pig iron producers to catch up with their orders. The forced delay to the furnaces, due to the shortage of coke and the distress into which the car shortage threw the shippers, had made all of the producers fall far behind their contracts on pig iron tonnage. The result was that the first three months of the year was given over to a contest between the new orders and the old for delivery.

In June apprehension began to appear lest the market would not afford that amount of business for the second half, which it was hoped would be the case. The result was that very little new business was done until after July 1, and then consumers showed a tendency to buy from hand to mouth. Those who have cared to analyze the situation are aware now that the price of semi-finished material had more to do with the checking of business than did the rather excessive cost of the price of the finished product, the pig iron market seeming to be the root of the evil. Toward the close of the third quarter the furnaces began to find the necessity for a reduction of the price of pig iron, and soon after that the furnaces in this territory took formal action, reducing the output 25 per cent during the last quarter. This was brought about by the lessened trade and by the large increase of productive capacity, 25 new furnaces having been blown in during the summer. The southern stacks came to play a big part also, shipping iron in here very freely, and carried on the war until prices dropped in the Birmingham district to $9 a ton. This brought about a corresponding revulsion against high prices in the north, with consequent reductions. No. 2 foundry iron in the north dropped from $24 to $14 in the Valleys. Bessemer and basic fell rapidly, but the lack of sales prevented the making of prices at the close. The market for the year closed with an apparent necessity of further reduced prices and output, but with some indication of a revival of business, which was, in the main, very favorable.

Finished Material.—The close of the year found the principal interest in the steel trade centered in steel bars. It is also evident, upon even a casual survey of the situation, that this grade has dominated the market all the year. There was a contention from the first. In most instances the buyers for delivery between July 1, 1902, and July 1, 1903, had been able to make terms with the mills when bar steel was at 1.50c., Pittsburg, for the bessemer quality. Immediately following the placing of those contracts the year before, steel bars had gone up $2 a ton. When it came, during the early part of last spring, to making contracts with the bar consumers, the steel men found that the advance was not liked, and that consumers were inclined to hold for the prices obtained the year before. The failure to agree brought out the first hesitation in the steel market. About October 1, the mills began accepting bar contracts, guaranteeing the price against a decline, and this precedent was followed for a month and a half, when a violent reduction of steel bars was made, carrying the basis down to 1.30c., Pittsburg, for Bessemer steel. This reduction had been brought about by the steady fall in bar iron and the fact that bar iron was being substituted for steel. Bar iron had fallen from 1.80c. to 1.30c., Youngstown, and the year closed with even that price being shaded.

The structural steel trade was influenced more than any other by the labor situation. It became evident early in the year that the contractors who were at work on buildings were having extreme difficulty to get along with the men and make any profit out of the construction. Business came to a halt in the middle of July, and trade was very slack thereafter. The year opened with the smaller mills demanding 2 to 2.25c. for structural at the mills for spot delivery, and getting it. The cancellation of orders with the larger mills, and the refusal or failure to specify against old contracts, soon placed the larger mills in position to make very prompt shipments, which cut the smaller mills out of their premiums. By May all mills were in the market for business, and no high prices were asked. By July specifications against old contracts were lagging seriously, and some of the smaller mills, which had sold at high figures, waived the premium, if the consumer would specify. The market closed with a very dull trade, with small orders, and demand being made for a reduction of prices.

Iron and Steel Production of the World.

The iron and steel production of Europe was good in 1903, conditions being generally favorable. The following tables show approximately the total pig iron and steel output of the world, the figures being given in metric tons, for purposes of comparison:

PIG IRON PRODUCTION OF THE WORLD. (IN METRIC TONS.)

Year.	Austria-Hungary.	Belgium.	Canada.	France.	Germany.	Italy.	Russia.
1899	1,323,999	1,036,185	95,582	2,578,400	7,160,203	19,218	2,708,749
1900	1,311,949	1,161,180	87,612	2,714,298	7,549,665	23,990	2,895,636
1901	1,300,000	765,420	248,896	2,388,823	7,785,887	25,000	2,807,972
1902	1,335,000	1,102,910	324,670	2,427,427	8,402,660	24,500	2,566,000
1903	1,355,000	1,216,500	265,418	2,827,668	10,085,634	28,250	2,210,000

Year.	Spain.	Sweden.	United Kingdom.	United States.	All Other Countries.	Total.
1899	266,385	467,727	9,572,178	13,838,634	625,000	39,722,560
1900	289,788	526,868	9,003,046	14,009,870	625,000	40,198,892
1901	294,118	528,375	7,977,459	16,132,408	635,000	40,889,358
1902	330,747	524,400	8,653,976	18,003,448	615,000	44,310,738
1903	380,284	489,700	8,952,183	18,297,400	625,000	46,733,039

STEEL PRODUCTION OF THE WORLD. (IN METRIC TONS.)

Year.	Austria-Hungary.	Belgium.	Canada.	France.	Germany.	Italy.	Russia.
1899	1,127,104	729,820	22,352	1,240,000	6,290,434	108,501	1,321,328
1900	1,145,654	655,199	23,954	1,565,164	6,645,869	115,887	1,830,260
1901	1,142,500	526,670	26,501	1,425,351	6,394,222	121,300	1,815,000
1902	1,143,900	776,875	184,950	1,635,300	7,780,682	119,500	1,730,250
1903	1,146,000	981,740	132,500	1,854,620	8,801,515	116,000	1,525,000

Year.	Spain.	Sweden.	United Kingdom.	United States.	All Other Countries.	Total.
1899	117,650	273,454	5,080,000	10,832,765	400,000	27,543,318
1900	144,355	300,536	5,130,800	10,382,069	400,000	28,342,294
1901	122,954	269,897	5,096,301	13,689,173	405,000	31,034,869
1902	163,564	283,500	5,102,420	15,186,406	412,000	34,519,347
1903	199,642	310,000	5,114,647	14,756,691	418,000	35,356,355

Some detailed notes on various foreign countries follow:

Belgium.—The output of iron and steel in Belgium is reported as below, in metric tons:

	1902.	1903.	Changes.
Pig iron	1,069,210	1,216,500	I. 147,290
Wrought iron	377,910	401,500	I. 23,640
Steel ingots	776,875	981,740	I. 204,865
Finished steel	755,880	958,860	I. 202,980
Totals	2,979,875	3,558,600	I. 578,775

The increases in all branches of the trade were considerable, being 13.8 per cent for pig iron, 26.4 per cent in steel ingots, 26.9 per cent in finished steel, and 6.3 per cent in wrought iron.

Canada.—Canadian iron companies furnish their reports of production to the American Iron & Steel Association. In 1903 these reports of pig iron production show a decrease of 54,139 gross tons, or nearly 17 per cent as compared with 1902, but an increase of 20,442 tons as compared with 1901.

The following table gives the total production of all kinds of pig iron (including spiegeleisen and ferromanganese) in Canada from 1894 to 1903.

Year.	Tons.	Year.	Tons.
1894	44,791	1899	94,077
1895	37,829	1900	86,090
1896	60,030	1901	244,976
1897	53,796	1902	319,557
1898	68,755	1903	265,418

The total production in 1903 amounted to 265,418 gross tons, against 319,557 tons in 1902. Of the total production in 1903, 247,905 tons were made with coke and 17,513 tons with charcoal. Nearly one-half of the total production was basic pig iron, 126,892 tons. Less than 1,000 tons of bessemer iron were made. Spiegeleisen and ferromanganese have not been made since 1899.

The unsold stocks of pig iron in Canada at the close of the year amounted to 19,168 tons.

On December 31, 1903, Canada had 15 completed blast-furnaces, of which 9 were in blast and 6 were idle. Of this total, 11 were equipped to use coke for fuel and 4 to use charcoal. In addition, 3 coke furnaces and 1 charcoal furnace were being built or were partly erected on December 31, but work on at least two of the furnaces had been suspended for some time.

France.—The report of the Comité des Forges, shows that in the year 1903 there was a considerable increase in the production of iron and steel in France. The pig iron made is reported as follows, in metric tons:

	1902.	1903.	Changes.
Foundry iron	419,543	569,239	I. 149,696
Forge iron and steel pig	2,007,884	2,258,429	I. 250,545
Totals	2,427,427	2,827,668	I. 400,241

Nearly all this iron is made with coke, only a few thousand tons of charcoal iron being produced.

The production of wrought iron for the two years was as follows, also in metric tons:

	1902.	1903.	Changes.
Charcoal forges	5,580	6,388	I. 808
Puddled iron	401,272	384,428	D. 16,844
From scrap, etc	218,974	205,115	D. 13,859
Totals	625,826	595,931	D. 29,895

Of the wrought iron reported in 1903, 45,995 tons were in sheets and plates; 549,936 tons were bars, angles, shapes and merchant iron.

The production of steel ingots for the year was as follows:

	1902.	1903.	Changes.
Converter	1,014,934	1,172,984	I. 158,050
Open-hearth	620,366	681,636	I. 61,270
Totals	1,635,300	1,854,620	I. 219,320

The report does not distinguish between acid and basic steel. The larger part of the French output, however, is acid steel.

The principal descriptions of finished steel products were as follows, in metric tons:

	1902.	1903.	Changes.
Bars and merchant steel	653,931	792,702	I. 138,771
Plates and sheets	276,287	290,204	I. 13,917
Rails	301,434	234,494	D. 66,940
Totals	1,231,652	1,317,400	I. 85,748

The statement of finished products is not quite complete, full statistics not being collected for some minor descriptions of material.

Germany.—The total production of pig iron by the German furnaces is reported by the German Iron & Steel Union as follows, in metric tons:

	1902.		1903.		Changes.	
	Tons.	Per cent.	Tons.	Per cent.	Tons.	Per cent.
Foundry iron	1,619,275	19.2	1,798,773	17.8	179,498	11.1
Forge iron	1,206,550	14.4	859,253	8.6	355,833	29.4
Steel pig			703,130	7.0		
Bessemer pig	387,334	4.6	446,701	4.4	59,367	15.3
Thomas (basic) iron	5,189,501	61.8	6,277,777	62.2	1,088,276	21.0
Total	8,402,660	100.0	10,085,634	100.0	1,682,974	20.0

In the classification above, for 1903, steel pig includes spiegeleisen, ferromanganese, ferrosilicon and all similar alloys employed in steel making and the like. Previous to 1903 such material was included under the head of forge iron.

A considerable quantity of Spanish and Swedish ore was imported into Germany during 1903, but the greater part of the production was from domestic ores. Germany has the advantage of large deposits of iron ore in different parts of the country; by far the most important being found in the minette ore basin of Luxemburg and the adjoining country. These ores are generally low grade, but have the advantage of being in large degree self-fluxing, requiring, therefore, only small quantities of limestone in the furnaces. The Germans, more than any other nation, make extended use of all by-products of the furnaces, and are thus able to keep costs down to a comparatively low figure.

The production of steel in Germany in 1903 was as follows, in metric tons:

	Acid.	Basic.	Total.
Converter ingots.........	435,327	5,473,195	5,908,522
Open-hearth ingots......	132,693	2,628,544	2,761,237
Castings...............	45,379	86.377	131,756
Total..............	613,399	8,188,116	8,801,515
Per cent..............	7.0	93.0	100.0

Dividing the steel again, according to methods of manufacture, we find that 67.1 per cent of the total was converter steel; 31.4 per cent open-hearth, and 1.5 per cent steel castings.

The German Iron & Steel Union estimates the consumption of pig iron for the year 1903 as in the table below. In this table the imports of iron and steel in finished forms, and of machinery, are reduced to terms of pig iron; that is, the quantity of pig iron required to produce these finished forms is estimated and stated. The figures are in metric tons:

	1902.	1903.	Changes.
Production................	8,529,900	10,017,901	I. 1,488,001
Imports as pig iron.........	174,990	218,327	I. 43,337
Imports in finished form......	192,160	208,889	I. 16,729
Total supply............	8,897,050	10,445,117	I. 1.548,067
Exports as pig iron.........	516,165	527,317	I. 11,152
Exports in finished form......	4,013,555	4,267,396	I. 253,841
Total exports...........	4,529,720	4,794,713	I. 264,993
Domestic consumption.....	4,367,330	5,650,404	I. 1,283,074

The exports in all forms were 53.1 per cent of the production in 1902, the proportion decreasing to 47.9 per cent in 1903; although there was an actual increase in the quantities exported. It appears also, that in 1903, 89 per cent of the exports were in the forms of finished material, or machinery, only 11 per cent being made in the form of pig iron.

The production of pig iron per capita in Germany in 1903 was 173.9 kg., against 149.6 kg. in 1902. The approximate consumption was 98.1 kg. per capita, against 76.6 kg. in the preceding year.

Spain.—Statistics of iron ore production in Spain, as reported by Don Adriano Contreras in the *Revista Minera,* are given below, in metric tons:

	1902.	1903.	Changes.
Vizcaya....................	5,059,405	4,760,000	D. 299,405
Santander..................	1,133,530	1,360,000	I. 226,470
Murcia.....................	629,421	735,000	I. 105,579
Almeria and Granada........	365,945	725,000	I. 359,055
Other provinces.............	716,254	898,600	I. 182,346
Total mined............	7,904,555	8,478,600	I. 574,045
Iron ore consumed..........	730,869	830,665	I. 99,796
Iron ore exported...........	7,560,020	7,692,214	I. 132,194

The production of iron and steel in various forms is reported as follows, in metric tons:

	1902.	1903.	Changes.
Pig iron	330,747	380,284	I. 49,537
Bessemer steel	103,389	105,263	I. 1,874
Open-hearth steel	60,175	94,379	I. 34,204
Total steel ingots	163,564	199,642	I. 36,078
Wrought iron	53,252	53,288	I. 36
Finished iron and steel	230,696	262,729	I. 32,033

The chief exports in 1903 were: To Great Britain, 4,947,028 tons; Germany, 1,889,329; France, 415,757; Belgium, 321,994; United States, 101,038 tons.

Of the pig iron produced in 1903, 22,000 tons were made with charcoal; the rest with coke. There were 18 furnaces in blast during the year.

Exports of pig iron were 50,188 tons in 1903, against 31,526 tons in 1902. Exports of finished iron and steel, chiefly bars, were 14,258 tons in 1903, against 11,329 tons in 1902.

The Sociedad de Altos Hornos de Vizcaya made 7,508 tons of tin plates in 1903. The Compañia Basconia also reported 82,553 boxes of tin plates, or about 4,300 tons, made last year.

Sweden.—The Swedish Iron Manufacturers' Association gives the following statement of iron and steel production in Sweden for the year, in metric tons:

	1902.	1903.	Changes.
Pig iron	524,400	489,700	D. 34,700
Iron blooms	183,600	191,300	I. 7,700
Bessemer steel	85,200	84,800	D. 400
Open-hearth steel	198,300	225,200	I. 26,900

There were in operation in 1903, a total of 98 blast furnaces, 292 puddling furnaces and bloom forges, 19 bessemer steel converters and 46 open-hearth furnaces.

United Kingdom.—The report of the British Iron Trade Association gives the production of pig iron in the United Kingdom as follows, in long tons:

	1902.		1903.		Changes.	
	Tons.	Per cent.	Tons.	Per cent.	Tons.	Per cent.
Forge and foundry	3,860,494	45.0	3,875,826	44.0	I. 15,332	D. 1.0
Bessemer pig	3,648,948	42.5	3,760,422	42.7	I. 111,474	I. 0.2
Basic pig	892,218	10.4	991,610	11.3	I. 99,392	I. 0.9
Spiegeleisen	185,033	2.1	183,346	2.0	D. 1,687	D. 0.1
Totals	8,586,693	100.0	8,811,204	100.0	I. 224,511	....

The increase was chiefly in pig iron intended for conversion into steel, forge and foundry iron production being almost stationary.

The approximate consumption of pig iron in 1903 may be calculated as follows:

Stocks, January 1	234,614
Production	8,811,204
Imports	130,280
Total supply	9,176,098
Exports	1,065,473
Approximate consumption	7,869,314
Total	8,934,787
Stocks, December 31	241,311

The consumption includes, of course, pig iron converted into wrought iron, steel and other finished forms. The stocks reported are those in public stores.

The production of steel in the United Kingdom was as follows, in long tons:

	1902.		1903.	
	Tons.	Per cent.	Tons.	Per cent.
Bessemer	1,825,779	37.2	1,910,018	38.0
Open-hearth	3,083,288	62.8	3,124,083	62.0
Total	4,909,067	100.0	5,034,101	100.0

The increase in bessemer, or converter, steel was 84,239 tons; while that in open-hearth steel was 40,795 tons, being proportionally less than in bessemer. The total increase in 1903 was 125,034 tons, or 2.5 per cent only.

The proportions of steel made by the acid and basic processes during 1903 were as follows:

	Acid.		Basic.	
	Tons.	Per cent.	Tons.	Per cent.
Converter	1,316,915	26.2	593,103	11.8
Open-hearth	2,613,274	51.9	510,809	10.1
Totals	3,930,189	78.1	1,103,912	21.9

The proportions of finished steel made by the two processes are as follows, in long tons:

	Bessemer.	Open-hearth.	Total.
Blooms and billets	239,119	400,664	639,783
Rails	1,061,441	84,942	1,146,383
Bars	221,283	537,745	759,028
Merchant steel	125,444	169,394	294,838
Plates and angles	21,840	1,248,079	1,269,919
Totals	1,669,127	2,440,824	4,109,951

Bessemer steel continues to find its most important use in the manufacture of rails; while open-hearth metal is preferred for plates and structural material.

The production of wrought, or puddled, iron was as follows, in long tons:

District.	1902.	1903.	Changes.
Scotland	225,900	196,078	D. 29,822
Cleveland	135,400	119,087	D. 16,313
Lancashire	135,090	132,588	D. 2,502
South Staffordshire	238,046	210,219	D. 27,827
North Staffordshire	105,777	95,600	D. 10,177
Yorkshire	76,953	124,341	I. 47,388
Derbyshire	38,412	34,113	D. 4,299
Shropshire, etc.	32,700	38,367	I. 5,667
Totals	988,278	950,393	D. 37,885

The chief items of production in 1903 were, in the order given, bars, wire-rods, sheets and hoops. At the close of the year 1,147 puddling furnaces were in operation and 308 were not in use.

Imports of iron ore, in detail, were as follows, in long tons:

	1902.	1903.	Changes.
Spain	5,309,733	4,945,086	D. 364,647
Greece	335,824	316,648	D. 19,176
Sweden	167,083	244,999	I. 77,916
Algeria	215,632	222,619	I. 6,987
France	66,172	130,078	I. 63,906
Norway	624	123,611	I. 122,987
Italy	182,053	111,197	D. 70,856
Newfoundland	91,317	49,536	D. 41,731
Other countries	86,319	107,204	I. 20,935
Total	6,454,757	6,251,078	D. 203,679

Among the other countries were Germany, Turkey and Portugal. No ore was imported from the United States in 1903 and only 42 tons in the preceding year.

Other Countries.—In Russia the iron and steel trade was very much depressed during the year. In Austria-Hungary the conditions were good, and a slight increase was shown.

Metallurgical Progress.—So much of the energy embodied in the trade during the year was devoted to the increase in output that no important metallurgical changes can be reported. Several important new plants, including blast furnaces and steel works, were completed and put into operation, and there was a general extension of production based upon the extraordinary demand of the previous two years. An important establishment recently put in operation was the Clairton plant, owned by the Clairton Steel Company and controlled by the Crucible Steel Company of America. The great works of the Lackawanna Steel Company, at Buffalo, were not quite completed, but a portion of them have been put in operation. An important feature in this plant is the utilization of the waste gases from the blast furnaces for the production of power. It is expected that some 30,000 h. p. will be obtained, part of which will be used to furnish blast and the balance to generate electricity, to be transmitted to different parts of the works where power is needed.

Abroad there are not many important metallurgical changes to be noted. The use of blast-furnace gas is extending in Belgium, France and Germany, and is being introduced, to a certain extent, in British furnaces. Experiments continue to be made in England with the Talbot continuous steel process, and some improvements are said to have been made. The Edison magnetic concentrating plant for concentrating and separating the impurities from Norwegian ores, in which a large amount of British capital was invested, is not yet in commercial operation. Further experiments have been made in smelting ores by electricity; no especial progress can be reported in this direction.

The microscopic investigation of iron and its alloys was continued by Sauveur, Howe, Osmond, Hadfield, Wedding, von Juptner, and others, but with no special discoveries.

The Canadian Government undertook through a commission headed by Doctor Haanel, the Dominion inspector of mines, to investigate the progress and present condition of electric smelting of iron ores, and of the manufacture of steel in electric furnaces. The object was, if possible, to secure the utilization of the iron ore deposits of northern Ontario in connection with the enormous water power existing on the Ottawa and other rivers in the same section. The report, however, was not published until after the conclusion of the year.

LEAD.

BY D. H. NEWLAND.

The production of lead of all kinds in the United States in 1903 was 276,-694 short tons, as compared with 280,524 short tons in 1902. The decrease amounted to 3,830 tons. Of desilverized, soft and antimonial leads, the output in 1903 and 1902, respectively, was as follows: Desilverized, 188,943, against 199,615 tons; soft, 78,298, against 70,424 tons; antimonial, 9,453, against 10,485 tons. There was thus a small increase in the output of soft lead, which was more than counterbalanced by the falling off in the production of desilverized and antimonial leads. In addition to the above total of lead smelted from domestic ores, there was an output in 1903 of 92,794 short tons of desilverized lead made from foreign ores and bullion.

STATISTICS OF LEAD IN THE UNITED STATES (SHORT TONS).

Year.	Produced from Domestic Ores.				Import'd in Ores and Bullion.	Total Supply.	Exported in all Forms.
	Desilverized.	Soft.	Antimonial.(a)	Totals.			
1899.	171,495	40,508	7,377	217,085	76,423	317,196	74,944
1900.	221,278	47,923	9,906	279,107	114,397	425,824	100,288
1901.	211,368	57,898	10,656	279,922	112,471	458,033	100,026
1902.	199,615	70,424	10,485	280,524	107,715	458,456	82,238
1903.	188,943	78,298	9,453	276,694	106,407	418,601	81,971

(a) The entire production of antimonial lead is entered as of domestic production, although part of it is of foreign origin.

PRODUCTION, CONSUMPTION AND STOCKS OF LEAD (SHORT TONS.)

Production and Consumption of Lead.	1902.	1903.
Production.		
Desilverized	199,615	188,943
Soft	70,424	78,298
Antimonial	10,485	9,453
Total production	280,524	276,694
Add stocks, Jan. 1	70,316	30,500
Add net foreign	13,534	29,545
Net total supplies	364,374	336,739
Domestic lead exported	3,271	56
Estimated consumption	330,603	315,683
Total	333,874	315,739
Stocks, Dec. 31	30,500	21,000

Movement of Foreign Lead.	1902.	1903.
Imports.		
Lead, metallic	2,529	3,023
Lead in ores and base bullion	105,186	103,384
Total imports	107,715	106,407
Less re-exports of foreign	78,967	81,915
Less smelters' allowance on lead re-exported	7,897	8,192
Total deductions	86,864	90,107
Net imports	20,851	16,300
Add lead in bond, Jan. 1	16,622	23,939
Total supply	37,473	40,239
Deduct lead in bond, Dec. 31	23,939	10,694
Approximate consumption of foreign	13,534	29,545

The most notable feature of the year's developments was the increased activity in the soft lead districts of Missouri, particularly in the southeastern district, which have benefitted largely from the high prices of pig lead in the New York market. It is expected that this State will make a still larger output during the current year. In the Cœur d'Alene district of Idaho the mining industry was also prosperous, and the production exceeded that of the previous year. Colorado showed a small decrease, principally due to the decline in the shipments from Leadville.

General Review of the Industry in 1903.

BY WALTER RENTON INGALLS.

The lead business of the United States is now almost completely in the hands of the American Smelting & Refining Company and the Missouri producers. The former smelts nearly all of the silver-lead ore that is produced. It has certain affiliated mining interests; but, while being far from controlling all the mines, by direct or indirect ownership, it is able to dictate the production of the outside interests, by virtue of its possession of almost all the smelting capacity. The Selby Smelting & Lead Company, of San Francisco, and the Balbach Smelting & Refining Company, of Newark, N. J., are the only important concerns outside of the trust, and their field of operation is naturally limited. The Missouri producers make non-argentiferous lead, which, for the most part, they both mine and smelt. They are content to conform to the price schedule established by the American Smelting & Refining Company. The latter does not attempt to maintain the prices of pig lead at a constant level, but wisely raises and lowers it according to the demand, and, on the other hand, regulates the production of ore by establishing the price to be paid to the miner. The business is therefore governed perfectly, subject to the limitation of the price for lead in London and the necessary difference to prevent importations.

During the year ended April 30, 1903, the American Smelting & Refining Company bought ore containing 1,025,132 oz. gold, 63,389,438 oz. silver, 246,480 tons lead and 23,959 tons copper. From the sale of metals it realized $82,985,442, out of which there was a profit of $9,403,711, or about 11.3 per cent of the total receipts. After deducting charges for general expenses, repairs, betterments and new construction, there remained a net balance of $5,421,103 on the year's business. With the exception of a small tonnage of pig lead in bond for export, the company had no stock of refined metal on hand April 30, 1903, save what was in the form of ore and base bullion. There were at that time in operation smelting plants with a capacity of 3,720,000 tons of ore per annum, and refineries with a capacity of 340,000 tons of lead bullion and 36,000 tons of copper bullion per annum. There were held in reserve, fully equipped and in good repair, smelters of a capacity for

650,000 tons of ore per annum and refineries of a capacity for 125,000 tons of lead bullion. The policy of the American Smelting & Refining Company has been to concentrate its operations, and to this the increasing rate of its earnings is largely attributed. The great plant at Murray, Utah, was completed in 1902, and all the old works near Salt Lake were then abandoned. The Philadelphia plant at Pueblo and the plant at Argentine, Kan., have been closed. In July, 1903, there was a strike at the two works at Denver, which compelled both to be closed, and the company decided then to abandon the Grant plant. In the meanwhile, the plants at Durango and Leadville, Colo., have been greatly improved. Also, the company has lately purchased the plant at Everett, Wash. Under the present system, a single large and economical plant is run at each important center. The bullion is shipped for refining either to Omaha, Chicago or Perth Amboy.

Between the Atlantic and Pacific coasts, the only competitor with the trust for silver-lead ores is now the Ohio & Colorado Smelting & Refining Company, a new concern, which has six blast-furnaces, of aggregate capacity for about 750 tons of ore per day, at Salida, Colo. Its ore supply is derived chiefly from Leadville, but considerable quantities are obtained from elsewhere in Colorado and from other States. Additions were made to this plant in 1902. In Utah, however, the copper smelters are now taking a good deal of ore that formerly went to the Smelting & Refining Company, and one at least of these concerns intends to go into the silver-lead smelting business.

In the Missouri districts, where the ore is turned out exclusively in the form of high-grade, non-argentiferous concentrates, the smelting is done by a variety of methods. Four of the smelters now operating in the Southeast have blast-furnace plants, one has reverberatory furnaces, and one has Scotch hearths. In the Southwest, Scotch hearths are used exclusively. In the Southwest the ore, which comes from a large number of small producers, is purchased by public smelters located at Joplin, Mo., and Galena, Kan., save in the case of the Granby Mining & Smelting Company, which has its own plant at Granby, Mo. In the Southeast, all of the important mining companies have their own furnaces, while the small producers sell either to the larger ones or to the few public smelters who can afford to take ore from this market. Some ore is shipped to the Pennsylvania Smelting Company, at Pittsburg, Pa., and occasional lots go to the Balbach works, at Newark, New Jersey.

Three of the mining companies of southeastern Missouri have smelteries adjacent to their mines. The St. Joseph Lead Company, which also treats the ore of the Doe Run Lead Company, has a plant at Herculaneum, on the Mississippi river, part way between the mines and St. Louis. The other works are situated at or near St. Louis, and the tendency is to make that the principal smelting point. The lead has to go to St. Louis, and there is no difference in the cost of carriage, whether it go there in the form of ore or pigs, while taking it there in the form of ore saves the cost of sending the coal, coke and fluxes from St. Louis down to the mines.

During 1903 the large plant of the Federal Lead Company, at Alton, Ill., constructed in 1902, was put into good running order. All the ore from the Guggenheim interests is now smelted there, and the old plant at Cheltenham, purchased from the Missouri Smelting Company, is closed. The smeltery connected with the Markle Lead Works, at Granite City, was operated during a portion of the year, but after the organization of the United Lead Company it was closed, the ore formerly received there being diverted to the Federal Lead Company, at Alton, an allied interest. The St. Joseph Lead Company made additions to its plant at Herculaneum in anticipation of the increased output of its mines in 1904. The National Lead Company, which for several years has been considering the erection of new smelting works, finally decided to build at Collinsville, Ill., about 12 miles from East St. Louis, and its plant will be erected in 1904. Nothing has yet been given out as to the nature of the new works, but it is to be expected that it will be a modern Scotch-hearth plant, with bag-house attachment and blast-furnaces for working up the gray slag, much like the Federal plant at Alton.

About 70 per cent of the lead produced in the United States is derived originally from five districts—the Cœur d'Alene (Idaho), southeastern Missouri, Park City (Utah), Joplin (southwestern Missouri and southeastern Kansas), and Leadville (Colorado). The remainder of the output comes chiefly from other districts in the States of Idaho, Colorado, Utah and Missouri. The Cœur d'Alene, southeastern Missouri and Park City have resources which permit of a largely increased output, and the tendency is toward a greater production from those districts when market conditions are favorable, as they were during 1903. Utah also has important possibilities in the old Bingham camp, which was formerly a large producer of lead, but has not been so since the great copper deposits were opened in its mines. Lately, the operators have had their hands full in developing their copper business, but, that having been accomplished, there is a prospect of resuming work in the lead ore. The lead resources of the United States are certainly great, and at present production is governed by the price which can be got for pig lead, increasing when lead is high and decreasing when it is low.

Lead ore is sold in the United States in three ways. In southeastern Missouri it is sold on the basis of a percentage, usually 90 per cent of the lead shown by wet assay, at the South price for Missouri pig lead, less a certain returning charge, St. Louis delivery. In the Joplin district the ore is sold on direct bids of so much per ton, the bidder taking into account all the various factors of conversion into pig lead. In the Far West the ore is bought on a percentage basis, usually 90 per cent of its lead contents by fire assay, at an arbitrary price established by the Smelting & Refining Company, less a certain returning charge. For example, the rate on Cœur d'Alene ore might be 90 per cent of lead at 3.5c. per lb., less $18 per ton for freight and treatment.

At the beginning of 1902 the established price for lead in ore in Idaho, Colorado and Utah was 3.5c. per lb. In March, following the advances in the price for pig lead, the rate for lead in ore was raised first to 3.75c. and then to 3.90c. The Cœur d'Alene miners were given the advantage of this increase, although the output of most of them had been contracted up to September on the basis of 3.5c. With the reduction in the price of pig lead in November, the rate for lead in ore was reduced to 3.5c. The high price for lead prevailing throughout 1903 caused increased activity in all of the lead-producing districts, the silver-lead producers enjoying, moreover, the benefit of an important advance in the value of silver.

Lead Mining in the United States During 1903.

Colorado.—The production of lead in Colorado during 1903, as reported by E. L. White, the Commissioner of Mines, was 50,757 short tons, valued at $4,301,123, against 53,125 short tons, valued at $4,325,484, in 1902. The output for the two years was distributed by counties as follows:

County.	1902.		1903.		County.	1902.		1903.	
	Short Tons.	Value.	Short Tons.	Value.		Short Tons.	Value.	Short Tons.	Value.
Clear Creek	1,641	$133,556	1,726	$146,255	Pitkin....	12,487	$1,016,185	16,635	$1,409,644
Hinsdale ..	3,107	252,838	230	19,467	San Juan.	3,850	313,308	3,485	295,280
Lake	19,725	1,605,228	18,177	1,540,287	Others. ..	5,565	452,881	4,529	383,817
Mineral ...	4,646	378,065	4,300	364,409					
Ouray . . .	2,131	173,423	1,675	141,964	Total. . . .	53,152	$4,325,484	50,757	$4,301,123

There was marked activity in the Leadville district during 1903, and the progress of mining was less hampered by labor troubles than most camps in the State. The total tonnage for the district was about 850,000 tons, including 49,434 tons carbonate ores, 208,779 oxidized iron ores, 284,396 tons sulphides, 80,213 tons zinc ore, 99,884 tons silicious ores, and 3,836 tons manganese. The total valuation of the output of Lake county was $10,011,275.

Explorations with the diamond drill during 1903 proved the existence in the Leadville district of ore deposits of greater extent than any before explored. The opening of the Iron Silver Mining Company's shoots through the Moyer workings disclosed deposits of large area in all directions, demonstrating that the iron shoot extends across the hill. The new deposit is producing very largely, and the company paid good dividends in 1903, besides spending a large sum in development. The Midas-Coronado-Northern combination, which was effected early in the year, has been pushing work in the Leadville Basin, and drill holes sunk below the 660-ft. workings disclosed a large body of valuable ore. One of the important works of the year was the extension of the Yak tunnel to the No. 4 shaft of the Ibex, which it met at a depth of 1,300 feet. The tunnel is now 11,000 feet long, and has its mouth in California Gulch. It has opened up a large gold belt property. The Ibex mine made a heavy tonnage of oxidized and silicious material during 1903. A 500-foot shaft has been sunk on the Wells-Moyer placer, by the Reindell Company to meet the Rock and Dome shoot west of the fault. A large ore-shoot was opened in the Diamond mine, at a cost of $200,000. The Fryer Hill Mines Company very largely increased their output in 1903, having made a heavy tonnage of low grade ore. They are completing a new shaft at the Pride of the West. The Western Mining Company's properties, including the Wolftone, Maid, Adams and A. Y. & Minnie, have all been large producers, and the concentrating plant has been operated successfully. Early in the year considerable work was done on the large sulphide bodies at the Small Hopes, but later lessees were working several of the shafts. The New Monarch Company is about to ship heavily to the Salida smelter. The shaft is to be sunk to 2,000 feet. The Leadville Home Mining Company has made a large tonnage from low-grade iron ores, and has found new deposits by drilling. The Caribou has been successful in prospecting for more ore bodies below the present workings. The Starr and the Bon Air are now classed among the properties producing lead and iron ores. The La Plata mines in Rock Hill have been sold to Eastern parties. The Belgian-Frenchman Company was formed to operate the Louisville combination. The Bartlett 1,200-ft. tunnel on Sugar Loaf has been completed. Prospecting work has been satisfactory on the Big Gold and Little Louise properties, and also in the Horseshoe section. The magnetic concentration mill at the Resurrection has been entirely successful, enabling the Company to handle large bodies of low-grade ores. The American Smelting & Refining Company built a mill at the Arkansas Valley smelters, with a capacity of 300 tons daily of low-grade sulphides. The Ohio & Colorado Smelting & Refining Company have installed twelve new roasters at Salida. They recently purchased the Republic plant, and are doing a much increased business.

Idaho.—The production of lead as reported by Robert N. Bell, Inspector of Mines, amounted in 1903 to 110,429 short tons. This figure represents the lead contents of ores mined in the State, and an allowance must be made for losses in smelting in deriving the output of pig lead. Shoshone county, in which the Cœur d'Alene district is situated, contributed 106,760 tons to the total. A review of the year's progress in the Cœur d'Alene mines has been contributed by Mr. Stanly A. Easton and will be found on another page of this chapter. Aside from this district the most important mines are situated in the Wood River region of Blaine county. They produced 3,079 tons of lead in 1903. The discovery of rich ores in the Minnie Moore mine at Bellevue has led to renewed activity in the Wood River district, and over 500 men are now employed in development work. The Minnie Moore has shipped about thirty carloads of ore a month, one-half of which is high grade, assaying 70 per cent lead and 110 oz. silver per ton. Discoveries of lead ores were reported at the Gilmore mine in the Texas district and the Winnie mine of the Spring Mountain district, both in Lemhi county.

Kansas.—The output of lead ore in 1903, as reported by Prof. Erasmus Haworth, State Geologist, was 3,139 tons, valued at $169,122. The yield in pig lead was 2,198 short tons, valued at $186,226.

Missouri.—The output of lead ore in 1903 was 128,800 short tons, valued at $6,730,515. Of the total St. Francois county contributed 92,351 tons, Jasper county 20,974 tons, Madison county 7,083 tons and Washington county 2,387 tons. The ore from the Joplin district commanded an average price of $53 per ton, while the average in the southeastern district was $46.81 per ton. The lead and zinc mines of the State represent a capitalization of $57,515,000 and operate 816 shafts and 320 concentrating plants.

In the Joplin district the action of the Missouri-Kansas Miners' Association in attempting to curtail the production of zinc ore so as to maintain prices naturally affected the output of lead ore. The local price for lead ore was very high, being upward of $50 per ton. The high range of prices was due to competition among the local smelters, who bid against each other until there was little margin left between the value of lead in ore and in pigs. The Joplin ore, which is entirely a concentrator product, is of high grade, containing from 75 to 80 per cent lead by wet assay. The smelting conditions in this district are such that little ore can be taken out for reduction elsewhere.

In the southeastern district the year was a prosperous one, and the output surpassed the high record of 1902. The increase in production was due mainly to the growth and development of the older companies, although one new company entered the ranks of producers. Labor was scarce, and several strikes occurred, but they were not protracted. The most important event of the year was the opening of the Missouri Southern Railroad, which enters the heart of the Flat River district. It will not only introduce competition into the district, but will afford a short direct line to the choicest portion of the Illinois coal field.

Among the active companies, the St. Joseph Lead Company, which is the pioneer in working the low-grade ores of the district, made the largest output in its history. The roasting plant at Herculaneum has been enlarged and equipped with self-dumping trestles, and a new mill is under construction at the Hoffman or No. 12 shaft. The ore is now raised from a single shaft, instead of five as formerly, and compressed air locomotives are used for underground haulage. The Doe Run Lead Company operated three of its shafts and increased its output. The Desloge Lead Company completed and equipped its new No. 4 shaft which promises to become a large producer. The operations of the Central Lead Company were interrupted by a strike, although the output was nearly as large as in the previous year. Material improvements were made in the mill, and the mines connected with the new Missouri Southern Railroad. The National Lead Company completed its No. 4 shaft, which should enable it to make a larger production during the current year. The company proposes to erect its own smelter in East St. Louis.

The Federal Lead Company suffered considerably from shortage of labor which reduced its output. The Columbia Lead Company leased its property to the Commercial Lead Company, and the latter has some projects under way that will lead to an increased production in 1904. The Catherine Lead Company at Fredericktown and the North American Lead Company in the same district were active. The Mine La Motte property, under the new eastern management, has enlarged its milling and mining facilities. Among the companies in a preliminary stage of development, including the Union, Perricant, Elizabeth and Manhattan, little was done, as they are awaiting more favorable labor conditions.

Texas.—According to W. B. Phillips,[1] Director of the University of Texas Mineral Survey, the Bird mines near Alpine, Brewster county, have shipped some silver-bearing galena to El Paso, and the Shafter mine in Presidio county has contributed a small output. Active work is being done in the Sierra Diablo, El Paso county. In the northwestern part of Burnet county, 80 miles northwest of Austin, there is a deposit of galena which appears to be of commercial importance. The galena is carried by a coarse-grained friable green sand, lying immediately upon granite, and also by the limestone which overlies the green sand. Assays show that the yield in lead varies between 10 and 20 per cent.

Utah.—The new plant of the American Smelting & Refining Company at Murray, nine miles south of Salt Lake City, was operated to its full capacity during 1903, treating about 40,000 tons of ore per month. One of the largest shippers to the new smelter was the Gemini mine in the Tintic district, which produced a total of 1,350,000 tons of crude ore and paid $100,000 in dividends. This mine has now reached a depth of 1,650 ft. and is still in good ore. The Yankee Consolidated mine in the same district was also a large producer of silver-lead ores. At Park City the Daly-West and Silver King mines each shipped about 75,000 tons of ore; the former paid $1,332,000 in dividends with total receipts of $2,382,258. The Silver King distributed $1,300,000 in dividends. The Daly-Judge mine increased the capacity of its mill and made regular shipments throughout the year. Further details of the progress of mining in 1903 will be found in the review by Mr. James W. Neill on a subsequent page of this volume.

1 The Engineering and Mining Journal, March 3, 1904.

The Cœur D'Alene District in 1903.

BY STANLY A. EASTON.

The silver-lead mines of the Cœur d'Alene, Shoshone county, in northern Idaho, showed a production for the year 1903 of 106,760 short tons of lead and 5,751,613 oz. of silver. This is an increase over past years, and the outlook indicates an equal or even greater production in the immediate future.

The Cœur d'Alene has now become one of the most prosperous and attractive mining fields in the West, giving steady employment to 2,000 men in the district itself, and not less than 1,000 additional at the smelter plants treating the product, and in the allied industries. This condition has been brought about by the steady and consistent efforts of the mine operators, and of the better portion of the community, to eliminate the disorderly and lawless bodies of individuals, who in the past have so disturbed the peace and interfered with the operations of the mines of this district.

Among the events of interest during the year are the taking over of the Standard and Mammoth mines, on Cañon creek, and the Empire-State properties at Wardner and Burke by the Federal Mining & Smelting Company, formed for that purpose. It is expected that the consolidation of management and its resulting economies, with possibly a closer relationship between the producers and the smelting interests, will prove beneficial.

The completion during the year of the power-transmission line from Spokane Falls to Burke has furnished a power cheaper than steam and free from the uncertainties of coal production and transportation. The line has a total length of 101 miles, and at present is transmitting 1,600 h. p. It is a three-phase system, and operates at 45,000 volts. It is so arranged that it may be operated at 60,000 volts, with a corresponding increase of power transmitted.

As to the mines, the development of the Hercules, above Burke, is of special note, as it has given to the district additional productive territory and a virgin property of great promise. The mine, now developed to a depth of over 1,000 ft., has paid for its own development and equipment, and is operated without concentration, the ore being of such grade that shipping direct in a crude state is possible, with a large margin of profit.

The general parallelism of the veins or fracture system is a noteworthy feature of the district, as is also the apposition of the ore-bodies on different veins, a fact which should serve as a guide in future explorations. The country rock is uniformly quartzite, and is remarkably free from igneous intrusions, there being merely a few bosses of granite or syenite, and a few small dikes of recent basalt. In many places cleavage has been developed in the quartzite, and the bedding is almost destroyed. Local secondary silicification often occurs, particularly adjacent to ore-bodies, making an 'ore-bearing' quartzite easily recognized by the experienced underground man. Ripple and rain-drop marks have been readily recognized. The ore consists of crystallized and amorphous galena, in a quartzite gangue, with iron carbonate, a little blende, pyrite, marcasite, chalcopyrite, and occasionally gray copper. It is found within, or adjacent to, fractures in the quartzite, some being simple fractures, some fault-planes and some sheeting. The ore-shoots are large, the Morning mine, at Mullan, having a shoot approximately 1,500 ft. long, with a width of 8 ft. of stoping ground, and at the Bunker Hill & Sullivan mine, at Wardner, ore-bodies are worked 400 ft. long, with an average width of 30 ft. The ore always contains silver, but no gold. The silver content varies from a ratio of one-third of an ounce to 1 per cent in lead up to several hundred ounces per ton in the oxidized surface ores and those containing gray copper; nevertheless, in individual ore-bodies the proportion of silver remains quite constant throughout. Ore opened up at a depth of 2,000 ft. below the surface in the Bunker Hill & Sullivan mines, at Wardner, shows no general change in character or grade, and is really more free from foreign sulphides than that from the upper workings.

The following statement shows the results obtained by the productive properties of the Cœur d'Alene district in 1903. It has been compiled from the affidavits made to the county assessor by the managers of the respective properties.

RESULTS OF MINING OPERATIONS IN THE CŒUR D'ALENE DISTRICT IN 1903.

Mine.	Tons Extracted.	Gross Yield.	Cost of Extraction.	Reduction and Transportation.	Repairs and Construction.	Net Profit.	Net Loss.
Standard & Mammoth*	365,908	$2,544,918	$1,054,515	$839,507	$55,857	$595,038	....
Last Chance†	174,216	1,409,672	411,079	591,013	24,926	382,652	....
Tiger-Poorman†	110,958	580,477	330,803	209,289	19,348	21,036	....
Hercules	10,043	850,258	108,099	202,728	100,648	438,746	....
Morning	236,410	1,635,612	500,475	763,677	25,039	346,420	....
Bunker Hill & Sullivan	†32,297	1,604,538	585,284	676,357	55,398	287,497	....
Hecla	71,490	655,721	272,191	225,556	73,237	84,735	....
Cleveland	881	13,999	1,200	4,706	....	9,292	....
Frisco	94,188	465,287	232,335	220,420	5,555	....	$2,033
Cœur d'Alene D. Co	†1,918	98,552	79,209	51,561	6,619	....	38,838
Gold Hunter	34,816	166,000	114,279	57,247	5,346	....	10,873
California Con	780	39,184	21,919	13,273	4,385	....	394
Totals	1,133,905	$10,064,218	$5,811,388	$3,814,343	$376,394	$2,165,416	$52,138

*Owned by Federal Mining & Smelting Company.
†Concentrates.

Lead Mining in Foreign Countries During 1903.

Australia.—The production of lead from ores mined in New South Wales in 1903 is officially estimated at 92,293 long tons, valued at £1,063,817. This estimate is based upon reports from smelting and mining companies, but a large part of the total represents the lead contents of ores exported for treatment. In addition there were exported to Great Britain and the Continent 76,824 tons of concentrates, which are estimated to have contained 29,706 tons of lead, 14,625 tons of zinc and 1,736,512 oz. silver, but no data are available as to the actual amount of lead recovered. The production of lead was confined, as heretofore, mainly to the Broken Hill district, where the British, Proprietary, Block 10, Central and South mines were in operation. The output of the district was 1,100,514 tons of ore, from which were obtained 308,681 tons of concentrates and other crude products with an assay value of 7,733,373 oz. silver, 135,406 tons of lead, 35,495 tons of zinc and 2,135 oz. gold. Operations in the district were favored to some extent during the early part of the year by a slight increase in the prices of lead, silver and zinc, but the improvement was only temporary, as the quotations for lead fell off rapidly in the later months. The drought which prevailed in June, July and August caused an almost complete suspension of work for about three weeks. By using the accumulations of water in some of the old workings and by transporting water by train from South Australia the mines and mills were maintained in operation during the remainder of the dry period.

The British mine resumed activity in 1903. A large amount of development and prospecting work was done with favorable results. The Block 10 mine has been opened to a depth of 1,115 feet, where good ore was found, and arrangements have been made to continue the work of sinking to the 1215-ft. level. The company has nearly completed the construction of a new mill and power and electric plants. At Block 11 no ore was mined, attention being directed to the utilization of the zinc tailings which have accumulated in previous years. The Potter wet process is used. At the Central mine a magnetic separation plant comprising 20 Mechernich separators was in operation, handling about 1,000 tons of material weekly. The Broken Hill Proprietary mine has been opened to the 1,000-ft. level and about 12,000 tons of ore are being taken out per week. In opening the 800-ft. level a body of ore was encountered which so far has been proved for a width of 66 ft. During the half year ending November 30, 1903, the company earned a gross profit of £91,999 and net profits, after allowing for depreciation, of £72,084. The sum of £18,597 was spent in construction and improvements, and one dividend of 1s. per share, or £48,000, was distributed among the shareholders. The output of ore for the half year was 283,282 tons; the silver produced amounted to 2,419,367 oz., and the lead to 30,808 tons. The refinery at Port Pirie treated 30,824 tons of bullion, producing 2,476,753 oz. silver, 1,308 oz. gold, 29,583 tons of soft lead and 228 tons antimonial lead.

Outside of the Broken Hill district the most notable event of the year was the reopening of the Pinnacles mine by the Queensland Smelting Company, who intend to work it on a large scale. The ore from this mine carries little zinc, and a high silver extraction is obtained. The concentrates are smelted at Aldershot, Queensland.

The output of lead in Queensland in 1903 was 3,795 tons, nearly all of which came from the Herberton district. The principal producer was the New Chillagoe Mines & Railway Company which operates a number of mines besides copper and lead smelters. During the year a total of 60,802 tons of ore were smelted for a yield of 3,636 tons of lead, 2,121 tons of copper and 341,266 oz. of silver.

LEAD PRODUCTION OF THE WORLD. (*a*) (IN METRIC TONS.)

Year.	Australasia.	Austria.	Belgium.	Canada.	Chile.	France.	Germany.	Greece.	Hungary.
1898 ..	67,000	10,340	19,330	14,477	13	10,920	132,742	19,193	2,305
1899 ..	87,600	9,736	15,700	9,917	171	15,981	129,225	19,059	2,166
1900 ..	87,100	10,650	16,865	28,654	14	15,210	121,513	16,396	2,030
1901 ..	90,000	10,161	18,760	23,542	455	21,000	123,098	17,644	2,029
1902 ..	90,000	11,300	19,504	10,433	(*e*) 500	18,817	140,331	15,668	2,243

Year.	Italy.	Japan.	Mexico.	Russia.	Spain.	Sweden.	United Kingdom. Foreign Ores.	United Kingdom. Domestic Ores.	United States.	Totals.
1898 .	24,543	1,705	71,442	241	198,392	1,559	23,239	25,761	207,271	798,615
1899 .	20,543	1,989	84,656	322	184,007	1,606	17,571	23,929	196,938	820,873
1900 .	23,763	1,877	63,827	221	176,600	1,424	10,738	24,762	253,204	854,407
1901 .	25,796	1,806	94,194	(*e*)250	169,294	988	19,639	20,361	253,944	892,955
1902 .	26,494	(*e*)1,800	106,805	(*e*)250	177,560	(*e*)1,000	9,113	17,987	254,489	926,895

(*a*) From official reports of the respective governments. (*e*) Estimated.

PRODUCTION, IMPORTS, EXPORTS AND CONSUMPTION OF LEAD IN THE CHIEF COUNTRIES OF THE WORLD. (IN METRIC TONS.)

		Austria-Hungary.	Belgium	France.	Germany.	Italy.	Russia.	Spain.	United Kingdom.	United States.
1901	Production	12,090	18,760	21,000	123,098	25,796	250	169,294	40,000	253,944
	Imports...	11,033	44,000	59,051	52,886	2,926	22,550	*Nil.*	221,549	102,033
	Totals	23,123	62,760	80,051	175,984	28,722	22,800	169,294	261,549	355,977
	Exports...	68	42,600	648	20,820	4,463	*Nil.*	151,993	18,426	90,520
	C'ns'mpt'n	23,055	20,160	79,403	155,164	24,259	22,800	17,301	243,123	265,457
1902	Production	13,543	19,500	18,817	140,331	26,494	250	177,560	27,100	254,489
	Imports...	8,706	53,000	72,730	39,006	7,563	23,000	*Nil.*	235,522	91,410
	Totals	22,249	72,500	91,547	179,337	34,057	23,250	177,560	262,622	345,899
	Exports...	53	50,000	6,454	23,100	5,650	*Nil.*	172,480	24,408	74,606
	C'ns'mpt'n	22,196	22,500	85,093	156,237	28,407	23,250	5,080	238,214	271,293

Austria.—The production of pig lead in 1903 was 12,162 metric tons, valued at $800,899, an increase of 898 tons and $94,902 over the corresponding figures for the previous year. In addition there was produced, in 1903, 923 tons of litharge, valued at $63,712.

Canada.—The total value of the lead produced in British Columbia up to the close of 1903 was $11,137,065. The production for 1903 was the lowest in eight years, amounting to 9,045 short tons, valued at $689,744. The production of the Province since 1893 has been as follows:

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
	Short Tons.		Short Tons.		Short Tons.		Short Tons.
1893.....	1,068	1896..	12,100	1899..	10,931	1902..	11,268
1894.....	2,831	1897..	19,420	1900..	31,679	1903..	9,045
1895.....	8,238	1898..	15,847	1901..	25,792	Total	148,219

The shortage for 1903 is largely due to the shut down of the mines in the Fort Steele division, which produced 14,565 tons in 1901 and only 359 tons in 1903. The Slocan district also figured largely in the shortage, its product in 1903 being 4,900 tons, or less than half the output three years ago. The Ainsworth district produced 30 per cent more lead than in previous years, but the ore is low grade. A detailed review of the year's developments in lead mining in British Columbia will be found on a subsequent page of this volume.

In order to stimulate the production of lead the Dominion Parliament has established a bounty of 75c. per 100 lbs. on lead mined and smelted in Canada, said bounty to be subject to reduction if the market price of lead exceeds £12 10s. per long ton in London. On a 30 per cent ore this bounty amounts to $4.50 per ton, and there is increased activity at many mines in consequence.

France.—The production of lead in 1902 was 18,817 metric tons, valued at $1,265,450, which was obtained from the treatment of 15,500 tons domestic ores and 22,100 tons of imported ores. The principal lead mine in France is situated at Pontpean, department of Ille-et-Vilaine; there are smaller mines at Pierrefitte in Hautes-Pyrenées, Peyrebrune in Tarn, and at Sentein in Ariège. The smelting works are situated at Coueron (Société des Mines et Fonderies de Pontgibaud) and in the department of Pas-de-Calais (Société des Mines de Malfidano).

Germany.—The production of pig lead in 1903 was 145,319 metric tons against 140,331 tons in 1902. The mining district of Breslau contributed 42,191 tons to the output in 1903, as compared with 30,210 tons in 1902, and the district of Bonn furnished 76,931 tons in 1903 and 83,743 tons in the previous year. In addition, the smelting works of Germany produced 4,428 metric tons of litharge, against 4,197 in 1902. The increase in production of pig lead was due entirely to the great advance made by the Silesian mines, where the lead is largely a by-product in zinc mining. The output from these mines has more than doubled in recent years.

Greece.—The production of lead in 1902 comprised 15,668 metric tons of argentiferous pig lead, valued at $1,410,120, and 19,527 tons of ore, valued at $144,500.

Mexico.—The production of lead in 1902 is reported officially at 106,805 metric tons. The large part of this total represents base bullion which is exported to the United States and refined in bond. Owing to the high tariff very little lead is now exported to this country in the form of ores, nearly all of the output being treated by local smelters. A review of the progress of lead mining in Mexico during 1903 will be found elsewhere in this volume.

Spain.—The production of lead in 1903, according to an official statement, was 175,109 metric tons, valued at $12,123,371, which compares with 177,560 metric tons, valued at $10,957,958, in 1902. The quantities of argentiferous lead included in the above totals were 56,687 tons and 74,370 tons respectively. The output in 1903 was distributed by provinces as follows: Murcia, 70,081 tons; Jaén, 47,060 tons; Cordoba, 34,493 tons; Almeria, 19,433 tons; and Guipuzcoa, 3,832 tons.

Turkey.—Argentiferous lead ores are mined at Balia in the *vilayet* of Brousse and at Avnie in the *caza* of Adramit. The mines at Balia, formerly owned by the Société du Laurium, were taken over in 1902 by the Société Anonyme Ottomane, which has since been engaged in productive operations. The ores are of complex character, consisting of galena, blende and pyrite in a gangue of limestone and eruptive rock. On an average they carry from 16 to 20 per cent lead and 8 per cent zinc. The entire output of lead is converted at the mine to pig lead, which is shipped to Frankfort, Germany, for refining. In 1903 the production was 63,000 tons of ore, yielding 7,600 tons of pig lead, 4,000 tons of galena and 1,900 tons of blende. The company's plant at Balia comprises a mill of 400 tons daily capacity for the production of lead concentrates, a Wetherill magnetic separator for making a blende product, and a smelting works with one 100-ton water-jacket lead furnace. Power is supplied by an electric plant situated 20 km. from the mines.

The New York Lead Market.

The average price of lead during the year under review was about 10 per cent higher than that of the preceding 12 months. Throughout the year all the lead-consuming industries have been very busy, and large quantities have gone into the manufacture of white lead, cables, pipes, sheets and babbitt metal. On the other hand, production has been well under control, thus obviating the necessity of exporting lead in order to maintain values at home, as has been the case in former years.

Mining operations, as far as new camps are concerned, and increases in old ones, have been more or less discouraged, owing to the fact that the capacity of the works outside of the American Smelting & Refining Company is still rather limited. The only exception in Missouri, which State has again benefited largely, and where the production is expected to show a further increase.

The year opened with the same quotations as ruled at the close of 1902, 4 to 4.05c. St. Louis, 4.05 to 4.10c. New York. Toward the end of February a very heavy demand set in, and early deliveries were difficult to obtain on account of the impossibility of getting proper shipping facilities from the railroad companies. This caused the American Smelting & Refining Company to put up its price $5 per ton on March 10, which advance was followed by another one of $6 per ton a week later.

The market remained steady for several weeks at 4.60@4.65c. New York, 4.55@4.575 St. Louis, until the end of April, when it became evident that at the low prices ruling abroad there was danger of foreign lead being imported, notwithstanding the duty of 2⅛c. Quotations were consequently reduced to 4.275 St. Louis, 4.35 New York, only to be followed by another drop of $5 per ton on June 17.

At the lower value established, a large business developed, and on September 15 prices were put up again to 4.40 New York, 4.325 St. Louis. This advance, however, caused consumers to restrict business, and this, together with the proximity of the foreign markets, necessitated another mark down of $6 per ton, which took place on November 15.

Inasmuch as stocks of refined lead were rather light and the demand improved considerably, prices were once more raised on December 14 to 4.25c. New York, 4.175c. St. Louis, which are the closing quotations of the year.

AVERAGE MONTHLY PRICES OF LEAD PER POUND IN NEW YORK.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
1899 ...	4.18	4.49	4.37	4.31	4.44	4.43	4.52	4.57	4.58	4.58	3.70	4.64	4.47
1900 ...	4.68	4.68	4.68	4.68	4.18	3.90	4.03	4.25	4.35	4.35	4.58	4.35	4.37
1901 ...	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.15	4.33
1902 ...	4.00	4.075	4.075	4.075	4.075	4.075	4.075	4.075	4.075	4.075	4.075	4.075	4.069
1903 ...	4.075	4.075	4.442	4.567	4.325	4.210	4.075	4.075	4.243	4.375	4.218	4.162	4.237

The London Lead Market.

Lead commenced the year with £10 17s. 6d. as the ruling price for soft foreign, English standing at about 2s. 6d. per ton more. Values remained steady during the first half of January, owing to the disinclination of holders to sell, but when prices had improved to about £11 7s. 6d., America came out as a seller, and prevented a further advance. Spot lead was very plentiful, and the chief demand was for distant delivery. February saw a complete change in the situation, America not only refusing to sell, but turning completely round, and buying in the London market. The trade with consumers was large, and considerable outside speculation took place, so that ultimately £12 6s. 3d. had to be paid for soft English, and March opened with a strong market at this figure, and with a renewed buying rush from consumers, there was another sharp run up to £13 15s. It was not until this figure had been reached that speculative holders were inclined to realize, this selling causing a decline to £13. Trade with consumers was very good at this time, and re-exports from America made it look doubtful if much metal would be available for export. April saw further sellings by dealers, and consumers, being fairly well covered, abstained from buying, so that there was a very rapid fall, without hardly any trade until £12 5s. was reached, but at this low level buyers were tempted, and the market rallied to £12 12s. 6d.; however, on the near approach of the holidays further weakness set in, and the month closed with £12 5s. as the nearest figure. Reports from America continued satisfactory, but this did not influence prices in London. May witnessed great apathy on behalf of consumers, so that prices gradually drifted downward in sympathy with the all-round decline in the other branches of trade. Closing prices were £11 7s. 6d. for soft foreign, being a fall of about £1 per ton on the month's trading.

June opened with very little demand, consumers during the first three weeks of the month remaining practically out of the market, so that values declined to £11 2s. 6d. for soft foreign; but just toward the end of the month cabled advices that the Broken Hill mines were likely to close down their works owing to want of water, caused a considerable amount of buying, which immediately drove the price to £12 2s. 6d. per ton; the closing price for the month was £11 15s. to £11 17s. 6d.

In July, notwithstanding the unchanged position in the Australian mines, the market declined somewhat, when consumers again withdrew, but when the level of £11 2s. 6d. had been reached, there was some fair buying on behalf of speculators, and this raised the price to about £11 12s. 6d. Toward the end of July, on the announcement that the Broken Hill mines had resumed work, there was a drop to £10 17s. 6d. for spot, arrivals on the Thames of some big parcels also helping the decline.

In August, notwithstanding the very heavy arrivals of large quantities, the market gained strength, touching at one time £11 8s. 9d. per ton, but eventually declining to about £11 3s. 9d. Consumption was particularly good on the Continent, and showed signs of improving in this market. In September the market was rather more active at the opening, especially for home made, prices remaining very steady throughout the month between £11 and £11 7s. 6d.

In October, dealers, who were apparently oversold, did their best to help prices down, but the consumers being equally anxious to cover their requirements, fluctuations were only to the extent of about 5s. per ton, with a quiet market. Metal for early delivery was somewhat scarce, owing to the large shipments which were made to Russia at this time.

November again saw a very steady market throughout, with hardly any fluctuation in value. Business with consumers was all of the hand-to-mouth scale, but the supplies being somewhat short kept the tone steady.

December opened with a steady market, the consumption for early delivery being quiet, as is usual at this time of year, but with rather more inclination on the part of buyers to secure metal for next year's delivery. The market closed rather firm, Spanish lead being quoted at £11 5s., with English lead at £11 7s. 6d. per ton.

White Lead, Red Lead, Litharge and Orange Mineral.

The production of lead pigments in the United States during 1903 showed a slight falling off from that of the previous year, although there was no material change in the output of the individual varieties. The production of white lead in oil was 84,800 short tons, against 89,737 tons in 1902, and of dry white lead 27,900 tons, against 24,976 tons in 1902. The total value of the

UNITED STATES: PRODUCTION OF RED LEAD, WHITE LEAD, LITHARGE AND ORANGE MINERAL.

Year.	Red Lead.		White Lead. (a)		Litharge.		Orange Mineral.	
	Short tons.	Value.	Short tons.	Value.	Short tons.	Value.	Short tons.	Value.
1899..	10,199	$1,070,895	103,466	$10,812,197	10,020	$1,032,060	928	$139,200
1900..	10,098	1,050,192	96,408	9,910,742	10,462	1,067,124	825	100,650
1901..	13,103	1,448,550	100,787	11,252,653	9,460	979,586	1,087	224,667
1902..	11,669	1,262,712	114,658	11,978,172	12,755	1,299,443	867	138,349
1903..	12,300	1,385,900	112,700	12,228,024	12,400	1,326,800	1,000	168,000

(a) Includes both dry and in oil.

white lead production was $12,228,024, against $11,978,172 in 1902. The output of litharge was 12,400 short tons, valued at $1,326,800 in 1903, against 12,755 tons, valued at $1,299,443 in 1902. Of red leather the output amounted to 12,300 short tons, valued at $1,385,900 in 1903 and 11,669 tons valued at $1,262,712 in 1902. The production of orange mineral was 1,000 short tons, valued at $168,000 in 1903, and 867 tons, valued at $138,349 in 1902.

In addition to the above products, the United States Reduction & Refining Company at Cañon City, Colo., reported an output in 1903 of 4,500 short tons zinc-lead, valued at $247,500, as compared with 4,000 tons, valued at

ANNUAL AVERAGE PRICE AT NEW YORK OF CORRODING PIG LEAD AND WHITE LEAD IN OIL.

Year.	Corroding Pig Lead.	White Lead in Oil.	Difference.	Year.	Corroding Pig Lead.	White Lead in Oil.	Difference.
	Per 100 lbs.	Per 100 lbs.	Per 100 lbs.		Per 100 lbs.	Per 100 lbs.	Per 100 lbs.
1894..	$3.28	$5.26	$1.98	1899..	$4.53	$5.35	$0.82
1895..	3.28	5.05	1.77	1900..	4.55	5.57	1.02
1896..	3.03	4.90	1.87	1901..	4.51	5.87	1.36
1897..	3.64	5.00	1.26	1902..	4.22	5.62	1.40
1898..	3.79	5.08	1.29	1903..	4.34	6.44	2.10

$225,000 in 1902. This pigment is a mixture of oxidized compounds of zinc and lead made by an oxidizing smelting of lead and zinc ores in a blast furnace of special design. There was also produced by the Picher Lead Company of Joplin, Mo., 4,295 short tons of 'sublimed lead,' against 4,736 tons in 1902. This pigment, which is sometimes classed as white lead, consists essentially of a mixture of lead sulphate and lead oxide obtained by special smelting of lead ores whereby this material is produced in addition to metallic lead. It can hardly be counted a by-product, as the furnace operations are conducted so as to yield a larger, rather than a smaller, output of the volatilized material.

UNITED STATES: IMPORTS OF RED LEAD, WHITE LEAD, LITHARGE AND ORANGE MINERAL.

Year.	Red Lead.		White Lead.		Litharge.		Orange Mineral.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1899..	1,021,573	$43,812	584,409	$30,211	55,127	$3,614	1,141,387	$58,242
1900..	549,551	25,532	456,872	28,366	77,314	2,852	1,068,793	61,885
1901..	485,467	19,370	384,673	21,226	49,306	1,873	977,644	52,409
1902..	1,075,839	37,383	506,423	25,320	88,115	2,908	997,494	49,060
1903..	1,152,715	40,846	518,945	28,103	42,756	1,464	756,741	36,407

Notes on the Lead Manufacturing Industry.

BY WALTER RENTON INGALLS.

The lead manufacturing business has become consolidated almost as thoroughly as the smelting business. The National Lead Company, organized upward of 10 years ago, acquired the majority of the corroding works in the United States, and has been for a long time the largest single consumer of pig lead. Besides white lead, it has manufactured red lead, litharge and orange mineral, and to some extent lead pipe and sheet lead. In 1898 one of its constituent companies, the St. Louis Smelting & Refining Company, acquired a large and valuable property at Flat River, in southeastern Missouri, and, after developing it on a grand scale, became a producer of pig lead, smelting the concentrates at the old works at Cheltenham, St. Louis, which, in former years, were run on silver-lead bullion from the West. The National Lead Company, in its manufacture of white lead, sticks to the old Dutch process. A few years ago the Bailey-Dutch process was taken up by a new concern, the Union Lead & Oil Company, backed by Messrs. Whitney, Ryan and Elkins, which also secured mining property in southeastern Missouri. This company planned to compete with the National, but its effect in the trade was not felt so quickly as was promised, although it is understood that the Bailey process proved fairly successful in practice.

Late in 1902 the scheme was developed to combine the two companies, and at the same time bring all of the other manufacturers of lead products into the consolidation. This scheme was promoted by the Guggenheims, and in the early part of this year it looked as if it would be consummated, but after hanging fire for a long time it finally fell through because of a dispute with the interests controlling the National Lead Company. Immediately afterward the United Lead Company was brought out, taking over the Union Lead & Oil Company; American Shot & Lead Company; Markle Lead Works, of Granite City, Ill.; Raymond Lead Company, of Chicago; Hoyt Metal Company, of St. Louis; Chadwick-Boston Lead Company, of Boston; James Robertson Lead Company, of Baltimore, Md.; Omaha Shot & Lead Works, of Omaha, Neb.; Northwestern Shot & Lead Works, of St. Paul, Minn.; Collier Shot Tower Works, of St. Louis, Mo.; Bailey & Farrell Shot Works, of Pittsburg, Pa.; Gibson & Price, of Cleveland, O.; Le Roy Shot & Lead Works, of New York; Sportsman's Shot Works, of Cincinnati, O.; Chicago Shot Tower Company, of Chicago, Ill.; Tatham & Brothers, of New York; E. W. Blatchford Company, of Chicago; Lanston Lead Works, of Chicago, and the McDougall White Lead Company, of Buffalo, N. Y. The Carter White Lead Company and the Picher Lead Company did not go into the consolidation.

The present situation in the lead-manufacturing business is, therefore, the existence of two great companies, which consume a large proportion of the pig-lead product, and a comparatively small number of independent manufacturers. The National Lead Company is the largest maker of white lead, red lead, litharge and orange mineral, and is also a producer of sheet lead and lead pipe. The United Lead Company controls, to a large extent, the manufacture of pipe, sheet, shot and the lead alloys, and is also a manufacturer of white lead. The National Lead Company mines and smelts a large portion of the pig lead it requires, while the United Lead Company obtains its supply from the American Smelting & Refining Company and the Federal Lead Company, with which concerns it is affiliated. The United Lead Company is preparing to go more extensively into the white-lead business, for which purpose it has begun the construction of a large plant at Granite City, Ill. This is likely to have an important effect on the white-lead trade, since the new production must go into consumption in some way, or displace a portion of the previous manufacturing capacity. A new plant for the manufacture of sheet, pipe, etc., is being erected at Perth Amboy, N. J.

The consumption of white lead in the United States has not, in recent years, shown the increase that it should, in view of the general prosperity and great activity in building that there has been. This is doubtless due, to a large extent, to the inroads that the makers of zinc-white and barytes pigments have made into the trade. The production of both zinc-white and barytes has increased in a somewhat greater ratio than has that of white lead; and their competition is not to be considered lightly. It is still an open question as to whether white lead or zinc-white is the superior pigment; it is conceded that barytes alone is inferior to either, except for special purposes; but there is no doubt that barytes is a valuable ingredient to be used in connection with the others, and some authorities hold that the best all-around paint is a mixture of the three.

Recent Improvements in Lead Smelting.

BY H. O. HOFMAN.

INTRODUCTORY.

New Publications.—'Lead and its Compounds,' by Thomas Lambert,[1] is a book that aims to cover almost everything that may be of interest to those having to do with lead and zinc. It is not quite clear for whom the book was intended. Surely not for those engaged in the various branches of the lead and zinc industries, as hoped by the author, as they are already better informed and can, when necessary, obtain better information on related subjects in any elementary book on chemical technology; nor for persons not engaged in the above branches, as they will obtain fanciful ideas of the present state of the science and art of working lead and zinc ores. It is a pity that the author should have wasted so much energy, as there cannot be any satisfactory return for it.

Physical Properties of Lead.—J. C. Humphrey,[2] continuing the work of Ewing and Rosenhain, has published the results of his studies of the effects of strain on the crystalline structure of lead.

Resistance of Lead to Sulphuric Acid.—F. C. Landvison[3] combats the old idea that small amounts of copper and antimony in lead give it the power to resist corrosion better than ordinary soft lead. Experiments with samples of lead, alloyed with varying amounts of copper and antimony, which were exposed to the fumes in two independent sulphuric acid plants showed that even small admixtures weakened the lead, and that the corrosion increased with the temperature, with the strength of the acid and with the percentage of intermixed alloy. Antimony seemed to have more harmful effects than copper. See also the experiments of Lunge.[4]

Lead Alloys as Bearing Metal.—G. H. Clamer[5] published a study of alloys suitable for bearing purposes. A good alloy must have at least two constituents, a hard one to support the load and a soft one to act as a plastic support for the harder grains. The metals used for this purpose are copper, tin, lead, zinc and antimony, and the alloys they form are classed as white metals and bronzes. Of the white metals, lead-antimony and lead-antimony-tin interest us here. The hardness of the lead-antimony alloys increases with the percentage of antimony. Alloys with an excess of lead over the eutectic (Pb, 87 per cent, Sb, 13 per cent) show more friction and less wear than those with an excess of antimony. The eutectic of lead and antimony has been adopted by the Pennsyl-

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1 Published by Scott, Greenwood & Company, London.

2 *Philosophical Transactions* of the Royal Society, 1902, pp. 225-240; *Proceedings* of the Royal Society, 1902, LXX, pp. 462-464; *Electro-Chemist and Metallurgist*, 1903, III, p. 270.

3 The Engineering and Mining Journal, November 21, 1903.

4 Hofman, 'Metallurgy of Lead,' 1899, pp. 14, 16.

5 *Journal* Franklin Institute, 1903, CLVI, pp. 49-77; The Engineering and Mining Journal, September 12, 1903.

vania Railroad as bearing alloy. According to Charpy, alloys with from 15 to 25 per cent antimony are best suited for bearings, while it is not safe to go above 25 per cent. Tin added to lead-antimony alloys makes them harder and more rigid without increasing the brittleness. As to bronzes, composed of copper, tin and lead, the rate of wear diminishes with the decrease of tin and with the increase of lead. A certain proportion of tin is necessary to prevent the liquation of lead and to give the alloy the required compressive strength; an excess over this proportion is harmful. With 30 per cent lead, alloys containing 5 per cent tin are made without difficulty; if the tin exceeds 6.10 per cent they are unsatisfactory. With 20 per cent lead, the tin may not exceed 7 per cent. The bronze finally adopted, as the result of a series of tests, for general purposes consists of Cu, 64 per cent; Sn, 5 per cent; Pb, 30 per cent; Ni, 1 per cent.

White Lead.—O. Herting[6] states that lead containing copper gives a white lead which is more or less greenish white, and that the presence of silver causes the paint to have a reddish shade.[7] He says also that bismuth-bearing lead may be used by the manufacturer of white lead, but that lead with 0.018 per cent Bi is not suited for making red lead.

Sources of Lead and Production in the United States.—W. R. Ingalls,[8] discussing in a valuable paper the three kinds of lead sold in the market and the localities from which are derived the lead ores, gives some data as to costs of production. Five districts produce 73.7 per cent of all the lead of the country, viz., Coeur D'Alene, Idaho, 26.3 per cent; Southeastern Missouri, 19.9 per cent; Leadville, Colorado, 6.9 per cent; Park City, Utah, 12.8 per cent; Joplin, Mo., 7.8 per cent. Most of the remaining 26.3 per cent comes from other camps in Idaho, Colorado and Utah.

Early Lead Smelting.—E. J. Dowlen[9] publishes some reminiscences on early blast furnace-practice in Utah and Colorado which are of historical interest.

Smelting in Denver, Colorado.—A. Lakes[10] gives a brief popular sketch of the operations carried on at the Omaha and Grant works, Denver, Colorado, illustrating his text with free-hand sketches.

Smelting in Spain.—E. H. Eriksson[11] describes lead smelting practice in Spain. He considers the example given characteristic for the country excepting some modern work carried on at Mazarron, Almeria and Linares. A blast-furnace has an internal crucible 3 ft. diameter and 3 ft. deep; 6 in. above the top of the crucible is the tuyere-level. The shaft here is 3 ft. 5 in. in diameter; there are three tuyeres 3 in. in diameter; the height from tuyeres to

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6 *Chemiker-Zeitung*, 1903, XXVII, p. 923.
7 Hofman, 'Metallurgy of Lead,' 1899, p. 14.
8 The Engineering and Mining Journal, November 28, 1903.
9 *Pacific Coast Miner*, February 14, 1903.
10 *Mines and Minerals*, 1903, XXIV, p. 238.
11 The Engineering and Mining Journal, November 14, 1903.

throat is 9 ft. 1 in., and the diameter at the throat 4 ft. 5 in. The smelting zone of the furnace is built of unbaked graphitic brick (being baked in place) and of red brick higher up. The mode of operating is peculiar. The charge for the day is made up and weighed out. In smelting, slag and matte are run out continously over a sand-trough, the lead collecting in the crucible. When the charges have been put through, the furnace is run down some distance, bars are introduced at the slag-level to hold up the charge, the lead is tapped, the crucible freed from accretions and filled with coke; then the tap-hole is closed, the bars are withdrawn and the blast is turned on again. The slag-matte is smelted in a separate blast-furnace with dry silver ore. The bullion assays 250 oz. silver per ton; the slag contains under 4 per cent CaO, over 45 per cent FeO, about 30 per cent SiO_2, from 5 to 10 per cent BaO, from 0.7 to 2.5 per cent Pb and from 2 to 3 oz. Ag per ton. The amount of coke used is 11 per cent on the charge (55 per cent ore and roasted matte, 13 per cent fluxes, 32 per cent slag), or 20 per cent on the ore. A furnace puts through from 10 to 15 tons charge or 7 tons ore in 24 hours. The yield in lead is from 76 to 85 per cent, in silver from 84 to 90 per cent.

Smelting in Mexico.—A. H. Bromly[12] describes with illustrations a primitive lead blast-furnace used near San Juan del Rio, Queretero, Mexico. The furnace is built of rough stone against a bank; it has an adobe front, is 2 ft. 4 in. by 16 in., and 6 ft. high; the crucible, 9 in. deep, is external and covered with charcoal; the distance from the single tuyere at the back to the discharge hole is 2 ft.; the blast is furnished by a trompe. The furnace puts through in 24 hours 7 tons 400 lb. of mixed ore. The base bullion is cupelled in a *vaso,* and the litharge sold locally for glazing pottery, or reduced to metal.

Smelting in Mongolia.—Y. T. Woo[13] describes the methods of silver mining and smelting used by the natives in Mongolia, giving illustrations of a primitive roasting kiln, a smelting furnace with bellows and a cupelling furnace. The paper is discussed by B. S. Lyman.

Sampling of Ores.—A. Harvey[14] discusses briefly automatic ore-sampling; he praises the Vezin[15] and New Brunton[15] sampling machines and describes the former, giving a number of illustrations. S. E. Bretherton[16] has patented a mechanical sampler by means of which he replaces the fractional-selection method of hand-sampling, i.e., taking out every second, fifth or tenth shovelful as a sample. The sampler consists of a horizontal wheel with buckets. These passing underneath the ore-chute take out the whole of the stream of ore at given intervals, and, being tipped mechanically at the opposite side, discharge their content into a sample-car. The sample is then reduced by a hand-sampling method.

12 *Transactions* Institution of Mining Engineers, 1901-02, XXII, p. 669; *Mining Reporter,* May 28, 1903.
13 *Transactions* American Institute Mining Engineers, XXXIII, pp. 755, 1038.
14 *Mining and Scientific Press,* June 6, 1903.
15 Hofman 'Metallurgy of Lead,' 1899, pp. 57 and 64.
16 *Mining and Scientific Press,* November 28, 1903.

Sampling of Hard Lead.—H. Nissensen and Ph. Siedler[17] discuss the uneven distribution of antimony in hard lead and the consequent difficulty of obtaining an average sample for analysis. At the silver-lead works of Stollberg, Westphalia, the hard lead produced contains from 18 to 22 per cent Sb; top, center and bottom samples of a bar gave, for example, 21.64, 19.68 and 12.08 per cent Sb. The accompanying figure represents diagramatically the fracture of a bar of hard lead; *a* is finely crystalline and has a silvery lustre; *e* is coarsely crystalline and extends often along the bottom of the mold; *d* is so finely granular as to appear amorphous, but it has a radiated structure, it is

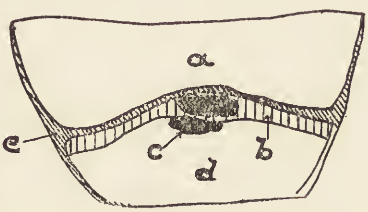

Fig. 1. Fracture of Hard Lead.

Fig. 2. Method of Sampling Bar.

dark gray; *c* are cavities caused by the large amount of shrinkage of antimonial lead upon cooling; *d* is amorphous. The crystalline parts are brittle, the amorphous bottom is soft and malleable. Analyses of the different parts are subjoined:

Bar No.	Parts.			
	e Per cent Sb.	a Per cent Sb.	b Per cent Sb.	d Per cent Sb.
1	21.75	21.78	11.48	11.40
2	......	21.60 (Cu=0.5)	11.76 (Cu=tr)	11.34 (Cu= tr)
3	19.07 (Cu=0.6)	18.12 (Cu=0.6)		11.94 (Cu=0.1)
4	......	20.44 (Cu=0.6)	......	11.27 (Cu=0.1)

Casting a bar in the usual way into a mold placed horizontally, allowing it to solidify in part and then raising the mold, some of the still liquid central portion began to exude through the porous surface; breaking through the latter, allowed the fluid portion to run out. This gave upon analysis 11.27 per cent Sb, while the wall of the cavity showed 20.44 per cent Sb. Referring to the work of Stead,[18] the authors find an explanation of this phenomenon in the formation of the eutectic of antimony and lead. This contains Sb 12.66 per cent, melts at 247° C. and has a sp. gr. of 10.48. When a bar of antimonial lead with from 18 to 22 per cent antimony is cast and allowed to solidify, antimony will separate out first and, having only a sp. gr. of 6.71, will tend to rise to the surface; some of it will adhere to the sides, which cool quickly by being

17 *Berg- und Hüttenmännische Zeitung*, 1903, p. 421.
18 *Journal* Society Chemical Industry, XVI, pp. 200-208, 506-509.

in contact with the iron mold. This explains the high percentage of antimony of parts *a* and *e*. According to the tables, parts *b* and *d* contain about the same amount of antimony, which is within 1 per cent of that of the eutectic. The impurities of commercial hard lead may explain the discrepancy. The reason that part *b* is coarser than *d* must be attributed to its cooling slowly, which favors coarser crystallization. In order to get around the uneven distribution of antimony in sampling, the authors advise to reserve every fifth or tenth bar of a lot, take saw-samples as shown in Fig. 2, sample down the sawings to a small bulk, weigh, rub to separate fine from coarse, weigh coarse and fine, analyze separately and calculate the average. The following table gives the results obtained by the method. An average of small dip samples taken at short intervals during casting, gave 19 per cent Sb.

Bar No.	Sawings analyzed direct. Sb %	Sizing of Sawings.				Sawings, Calculated Assay. Sb %
		Coarse.		Fine.		
		Wt. %	Sb. %	Wt. %	Sb. %	
1	17.50	69.22	18.47	30.78	14.60	17.28
2	19.08	58.11	21.25	41.89	14.52	18.40
3	19.00	56.08	21.00	43.92	17.18	19.33
4	18.50	59.02	20.64	40.98	18.24	18.24
Average.	18.52					18.31

Assaying in General.—A. W. Moss[19] gives a brief outline of weighing and sampling ores, and of sampling base bullion and gold bars. The notes contain little that is new. E. H. Miller, E. J. Hall and M. J. Falk[20] have published a paper on the reduction of lead from litharge in preliminary assays and the advantages of an oxide slag to which the reader must be referred.

Assay-Furnaces.—The Turner Brass Works[21] have brought out a gasolene crucible-assay furnace which, when set up, occupies a space of 5 by 12 in. and weighs 15.5 lb. packed ready for shipment.

The German Gold & Silver Parting Company of Frankfort[22] has brought out an oblong portable gasolene assay-furnace called 'Prospector.' It is 15 by 9 by 10 in., weighs 62 lb., stands on folding legs, and is suited for crucible and muffle work. The burner can be attached either at the crucible or the muffle end of the furnace. With the burner at the crucible end, Seger cone No. 6 (1,250° C.) is melted down in 45 minutes and No. 9 (1,310°) in 65 minutes; in the muffle, at the same time, cone No. 09 (970°) is fused in 30 minutes, No. 06 in 45 minutes, and No. 01 (1,130°) in 65 minutes. With the burner at the muffle end, Seger cone No. 01 (1,130°) is melted down in the muffle in 50

19 *Transactions* Australasian Institute of Mining Engineers, 1902, VIII, p. 92.
20 *Transactions* American Institute of Mining Engineers, 1903, XXXIV.
21 *Mining and Scientific Press*, June 27, 1903.
22 *Berg- und Hüttenmännische Zeitung*, 1903, p. 258; *Thonindustrie-Zeitung*, 1903, p. 451.

minutes, No. 3 (1,190°) in 65 minutes, and No. 5 (1,230°) in 75 minutes; the temperature of the crucible at the opposite end reaches 500°. The furnace holds a crucible 5.5 in. high and 3 in. wide (capacity 200 c.c. or 2.2 lb. metal), a muffle 5 in. long by 3.525 in. wide by 2.25 in. high, or a roasting-dish 4 in. long by 3.25 in. wide by 1.25 in. deep.

A. D. Barnhart[23] has constructed a circular gasolene melting furnace in which one or (with larger sizes) two blow-pipes are placed tangentially. This arrangement distributes the heat better than when the pipes are placed radially.

J. W. Hyde[24] patented a new form of scorifier-tongs which represent a simplification of the expensive (Judson) clamping tongs frequently found in assay offices.

Assay Fluxes.—A. D. Barnhart[25] advocates the use of crystallized borax as a cover and of gloss-borax as part of the charge in a crucible assay. Hydrated borax gives up its water at a low heat, swells, curls and forms a cover over the charge which prevents losses by sprouting. It is just this property of forming a stiff layer which makes it undesirable as a constituent of the charge.

Gold and Silver Assays.—H. A. Dickson[26] discussed in a general way the crucible-assay of gold ores.

P. G. Morgan[27] publishes an extensive paper on the sources of error in the fire assay of gold and silver ores. It contains many valuable hints and much good advice regarding sampling and assaying, but few, if any, new features. The sources of error referred to are those in taking the moisture and the assay sample, the errors liable to be made in roasting and grinding, errors by dusting, by the use of impure and wrong fluxes, by losses due to slagging and volatilization, by the imperfect removal of impurities from the bottom, and lastly by faulty parting, weighing and calculating of results.

W. G. Perkins[28] advocates the use of an all-fire method for the assay of gold and silver in blister copper, the copper charged first is matted at the bottom of the crucible by the addition of sulphur, and the matte then attacked by the fluxes covering the copper-sulphur charge. A charge for a 20-gram crucible is: S 800 milligrams, Cu 0.083 A.T., $Na(H)_2CO_3$ 0.5 A.T., PbO 8.5 A.T., SiO_2 0.5 A.T., salt cover. In the assay, silver and gold go into the lead button, some of the copper is oxidized and slagged, the lead button is scorified and cupelled. The mode of operating is as follows: Place crucibles in a dull-red muffle, raise the temperature gradually for 30 or 35 minutes (keeping atmosphere in muffle reducing), so that at the end of this time some salt will not be melted in the center of the charge, urge the fire so that in ten minutes the muffle will be a bright red, and the charge perfectly fused and quiet. The ad-

23 *Mining and Scientific Press*, May 30, 1903.
24 United States Patent No. 739,419, September 22, 1903.
25 *Mining and Scientific Press*, January 3, 1903.
26 *Transactions* Institution of Mining Engineers, 1901-02, XXII, p. 673.
27 *Mining Reporter*, January 29, February 5, 12, 19, 1903.
28 *Transactions* American Institute Mining Engineers, XXXIII, p. 670.

vantages claimed for the method are: that as to gold, the results are equal to those of the all-scorification method; that as to silver, they are equal to those of the combined dry and wet method; that gold and silver need not be determined separately; and that it is quick.

Influence of Bismuth on the Silver-Assay.—K. Sander[29] investigated the influence that bismuth has on the assay of silver ores by the crucible method. In the crucible-assay all the bismuth of the ore goes into the lead button, and many assayers believe that in cupelling some of the bismuth remains with the silver button. The following table gives the results of 23 cupellations:

No. of Test.	Cupel Charge.			Silver after Cupelling. Milligrams.	Loss in Silver. %	Remarks.
	Lead Grams.	Bismuth Grams.	Silver Milligrams.			
1	10	......	20.35	19.75	2.95	
2	10	0.102	21.00	20.35	3.10	
3	10	0.202	21.75	21.00	3.45	
4	10	......	19.75	19.10	3.30	Silver buttons of tests 1-3 were re-cupelled with 10 grams lead.
5	10	......	20.35	19.70	3.20	
6	10	......	21.00	20.15	4.05	
7	10	0.50	19.00	18.50	2.63	
8	10	......	19.92	19.45	2.35	
9	13	0.125	26.85	25.90	3.16	
10	13	......	24.55	22.75	7.33	Cupelled very hot.
11	10	0.20	25.90	24.00	7.33	
12	10	......	19.45	18.70	3.85	
13	15	0.10	50.35	48.50	3.67	
14	15	0.10	51.05	49.75	2.54	
15	15	0.10	51.50	49.95	3.00	
16	15	0.10	51.60	49.50	4.06	
17	15	......	48.25	46.55	3.52	
18	17	0.125	24.52	23.60	3.75	
19	17	0.125	25.30	24.55	2.96	
20	17	......	25.00	24.10	3.60	
21	17	0.125	25.95	25.10	3.30	
22	17	0.125	25.20	24.60	2.40	
23	17	......	25.00	24.35	2.60	

The average loss in silver by volatilization and cupel absorption in the presence of bismuth was 3.17 per cent; in the absence of it, 3.27 per cent. The table shows that bismuth, in the amounts usually found in ores, has no influence upon the assay. The presence of bismuth is easily recognized in a cold cupel, as the place which the silver button occupied will be colored brown and surrounded by concentric rings which are partly yellowish, partly blackish green. In order to test an ore for bismuth, 20 grams or more are assayed for lead, the button is dissolved in nitric acid, the lead precipitated with sulphuric acid, filtered and the filtrate made ammoniacal, when bismuth and a small amount of residual lead will fall out. The precipitate is dissolved in a small amount of hydrochloric acid and diluted with water; a turbidity shows the presence of bismuth.

Lead Assays.—Correspondent[30], assaying 700 samples of complex ores averaging zinc 30 per cent and lead 10 per cent, found that the volumetric method gave results 2.5 per cent higher in lead than the fire-assay. It does

29 *Berg- und Hüttenmännische Zeitung*, 1903, p. 81.
30 *Mining Reporter*, June 11, 1903.

seem strange that anybody should try to find the lead contents of such refractory ores by means of an ordinary fire-assay, also that the difference in favor of the wet method should not have been greater.

R. F. McElvenny and G. A. Izett[31] have carried on a series of experiments to ascertain the accuracy of the wet and dry methods for the determination of lead in ores. In the gravimetric wet methods, they weighed the lead as sulphate and chromate, and obtained more concordant results with the latter than with the former.

Ore No.	Ore Used, Grams.	Lead Sulphate Method.		Ore Used, Grams.	Bichromate Method.	
		Pb Per cent.	Pb Per cent.		Pb Per cent.	Pb Per cent.
1	1	80.47	80.65	0.250	81.10	81.23
2	1	64.00	63.80	0.250	64.35	64.42
3	1	37.10	36.95	0.500	37.22	37.00
4	1	29.82	29.62	0.500	30.10	30.00
5	1	24.93	24.80	1.000	24.29	24.82
6	1	15.86	15.75	1.000	16.00	15.95

Of the volumetric methods (molybdate, bichromate, permanganate, ferrocyanide) tried, the ferrocyanide gave the more satisfactory results, as seen in the subjoined table.

Ore No.	Molybdate Method.*			Bichromate Method.*			Permanganate Method.					Ferrocyanide Method.		
	Ore, Grams	Pb† Per cent.	Pb† Per cent.	Ore, Grams	Pb† Per cent.	Pb† Per cent.	Ore, Grams	Pb‡ Per cent.	Pb‡ Per cent.	Pb‡ Per cent.	Pb‡ Per cent.	Ore, Grams	Pb‡ Per cent.	Pb‡ Per cent.
1	0.500	81.90	82.00	0.250	81.3	81.4	0.500	76.4	75.9	80.9	80.85	0.500	81.3	81.4
2	0.500	64.90	65.10	0.250	64.3	64.3	0.500	62.1	61.8	64.3	64.40	0.500	64.4	64.4
3	0.500	37.60	37.70	0.500	37.3	37.2	0.500	35.0	34.6	37.2	37.00	0.500	37.4	37.1
4	1.000	30.30	30.50	0.500	30.2	30.3	1.000	30.0	29.5	30.2	30.30	1.000	30.2	30.3
5	1.000	25.10	25.10	1.000	24.9	24.8	1.000	23.6	23.9	24.6	24.80	1.000	24.7	24.8
6	1.000	16.20	16.10	1.000	16.2	16.1	1.000	14.9	15.3	15.5	15.90	1.000	16.3	16.2

* The results are affected by considerable amounts of iron.

† Lead sulphate dissolved in ammonium chloride, precipitated with aluminum, dissolved in nitric acid solution made alkaline, lead precipitated with oxalic acid, the oxalate dissolved and oxalic acid titrated.

‡ Lead sulphate dissolved in ammonium acetate, precipitated as oxalate and combined oxalic acid titrated.

A. W. Warwick[32] has much to say against the low results obtained by the fire-assay as against the volumetric methods. In an average of 10 assays the volumetric method gave 10.4 per cent, while the fire assay showed only 8.3 per cent, a difference of 2.1 per cent; in another set of 14 samples, the figures were 14.4 and 12.7 per cent, or 1.7 per cent in favor of the wet method. The

31 *Mining Reporter*, July 29, 1903.

32 *Proceedings* Colorado Scientific Society, VII, pp. 73, 77; *Mining Reporter*, July 9, 1903; *Mining and Scientific Press*, May 23, 1903.

tabulated results in the next paper reviewed make any comments unnecessary. It may, however, be accepted that with low-grade ores, wet methods will give results higher by 2 per cent than dry methods.

In the fire-assay method three flux mixtures (Nos. 1-3) were tested on eight ores (*a-h*) of very different compositions, the best flux (No. 3) then used with ores Nos. 1-6 (tested by wet methods) using the iron method and a muffle-furnace, and lastly, the effects of zinc, arsenic, bismuth, copper and antimony on the assays studied.

FLUX TESTS.

Ore.	Flux No. 1.		Flux No. 2.		Flux No. 3.	
	Pb %	Pb %	Pb %	Pb %	Pb %	Pb %
a	50.2	49.8	50.5	50.3	50.4	50.7
b	57.8	57.5	57.9	57.7	57.4	57.7
c	12.7	12.3	13.1	12.7	13.3	13.1
d	7.4	7.6	7.8	8.1	7.9	8.3
e	29.5	29.5	30.6	30.2	31.0	30.7
f	38.7	38.4	39.1	38.8	39.4	39.2
g	49.1	48.7	49.3	48.9	49.5	49.4
h	64.3	63.8	65.0	64.6	65.5	65.2

COMPOSITION OF FLUXES.

No.	Sodium Carbonate.	Sodium acid Carbonate.	Potassium Carbonate.	Potassium Acid Carbonate.	Flour.	Borax Glass.	Argols.
1	4	...	4	...	2	1	...
2	2	...	2	...	...	1	1
3	...	6.5	...	5	2.5	2.5	...

ASSAYS OF ORES NO. 1–6.

With Flux No. 3.

Ore.		Lead Per Cent.		
No.	Grams Used.			
1	10	77.8	78.2	78.3
2	10	62.4	62.0	62.1
3	10	34.7	34.4	35.1
4	10	28.0	27.8	27.8
5	10	23.6	23.3	23.3
6	10	14.4	14.4	14.6

The effect of zinc oxide added to the ore-charge in amounts to make these contain from 3 to 30 per cent did not have much effect upon the results. Arsenic added in forms of arsenious oxide up to 30 per cent of the weight of the charge made no changes in the figures. A few experiments with antimony gave no decided results. With bismuth using ore No. 4, and with copper using ore No. 3, the following results were obtained:

Ore No. 4.			Ore No. 3.		
Per Cent Bismuth Added.	Per Cent Lead Obtained.		Per Cent Copper Added.	Per Cent Lead Obtained.	
½	28.0	28.4	1	34.6	34.8
1	28.2	28.4	2	34.7	34.7
2	28.5	28.6	3	34.9	35.1
5	30.2	30.8	5	35.3	35.7
15	33.7	35.4	10	36.1	36.2

Separation of Galena and Chalcopyrite from Other Sulphides.—C. Boucher[33] shows that in heating a concentrate of galena, chalcopyrite, blende, arsenoyprite and pyrite with a mixture of three parts acid sodium sulphate and one part ammonium nitrate, galena and chalcopyrite alone will be oxidized. With galena, heating on a sand-bath is sufficient for oxidation, while with chalcopyrite a higher temperature is necessary after the first vigorous action on the sand-bath has ceased. The oxidized products are then separated from the undecomposed residue by leaching.

Determination of Lead, Tin and Antimony.—S. Burman[34] proposes the following method as an improvement over that of Finkener for determining lead, tin and antimony: Place 0.5 gram filings in a small beaker, cover with hydrochloric acid, add from 2 to 3 grams tartaric acid and then bromine until solution begins, and warm to a temperature of from 30 to 50° C. When solution is completed, add a few drops hydrochloric and nitric acids, warm until excess of bromine has been driven off and precipitate lead chloride with ten times the volume of solution of absolute alcohol; then filter, wash (using at first tartrate of alcohol) and weigh in a tared crucible. Dilute filtrate, boil until most of the alcohol has been volatilized, neutralize with ammonia, add from 10 to 16 grams sodium sulphide, then 1 c.c. hydrochloric acid, dilute to 700 or 800 c.c. and boil, when red sulphide of antimony will be precipitated. Add small quantities of hydrochloric acid until the precipitation is complete. Test the filtrate with hydrogen sulphide for antimony; if any is in solution, it will fall out immediately, while tin will be precipitated only later on. Dry the antimony sulphide, place in a Rose crucible and heat gently in a current of carbon dioxide to remove excess of sulphur. In case bismuth and copper are present, the antimony sulphide has to be dissolved in ammonia and re-precipitated. In the filtrate of the antimony sulphide, tin and arsenic are precipitated in the cold with hydrogen sulphide after acidulating. Arsenic sulphide is separated

33*Bulletin* Société Chimique, XXIX, 933; *Journal* Society Chemical Industry, XXII, p. 1209; The Engineering and Mining Journal, December 24, 1903.

34*Jernkontorets Annaler*, 1902, Bihang, p. 437; *Oesterreichische Zeitschrift fur Berg- und Hüttenwesen*, 1903, p. 417.

from tin sulphide by boiling with acid potassium sulphite and the precipitated tin sulphide filtered off and washed with hydrogen sulphide water containing ammonium acetate to give a clear filtrate; it is then dried, ignited in a porcelain crucible, freed from traces of sulphate by adding a piece of ammonium sulphate of the size of a pea and then heated to constant weight. Usually very little arsenic is present in these alloys. Instead of determining the arsenic in the filtrate of the tin sulphide, it is preferable to use fresh material and ascertain the amount by the usual method of distilling with hydrochloric acid, ferric chloride and ferrous sulphate.

Slag Analyses.—Th. Smith[35] reports on the results obtained from co-operative analytical work on copper slags, a plan proposed by him[36] to find the sources of error which cause the results of some of the best known analysts to disagree. The slag-sample sent out had been chilled when taken from the furnace, in order to make it readily soluble in acids; nevertheless, it contained a small proportion which was not decomposed by acids alone. For comparison, the analysis of Dr. F. Hillebrand, of the United States Geological Survey, was taken as standard. It is marked as such in the subjoined table of results:

Designation.	SiO_2	Fe	Al_2O_3	CaO	MgO	Zn	Mn	Cu	S
Standard.	33.78	31.68	4.07	12.48	2.87	2.83	0.41	0.40	1.69
3	34.32	31.76	3.24	11.08	2.24	2.59	0.86	0.42	1.98
6	34.60	31.50	7.00	13.00	1.55	2.27	0.47	0.39	1.49
7	34.59	31.82	4.25[1] 6.21[2]	12.47	2.95	2.80	0.44	0.35	1.64
8	33.60	32.05	4.90	.....	.....	...	.....	0.39	....
9	33.17	32.08	4.80[1] 5.04[2]	12.69	2.82	2.83	1.53	0.36	1.71
12	34.10	30.80	4.80	11.70	1.98	1.87	1.29	0.36	1.84
13	32.38	30.33	8.27	4.435	0.115	0.04	Trace	0.10	1.40
15	34.53	9.15	.....	.....	.....	.....	0.52	....	0.87
17	33.68	30.83	7.16	11.40	2.17	2.49	0.11	0.37	1.68
20	33.60	31.80	4.70	12.70	2.30	3.00	0.50	0.35	1.90
23	32.00	31.70	5.00	12.60	1.20	3.30	1.30	0.24	1.70
27	32.80	31.70	4.42	12.25	2.71	2.93	0.58	....	1.79
29	34.50	31.58	4.30	12.70	2.35	4.25	0.62	0.45	1.95
30	31.27	32.07	4.31	13.53	3.21	3.10	0.67	0.41	1.61
31	32.15	32.20	5.20	12.25	2.96	3.00	0.60	0.46	1.75
33	33.99	31.27	4.64	12.14	3.15	2.45	0.50	0.29	1.48
34	34.70	31.20	4.83	11.69	2.88	2.42	0.32	0.25	1.80
35	31.75	.....	.....	.....	.....	.....	.....	0.20	....
36	34.28	31.14	4.08	12.28	2.59	2.97	0.46	0.45	1.82
37	35.15	31.90	3.76	10.73	2.57	3.25	0.50	0.40	1.71
39	33.39	32.04	5.72	12.38	2.57	1.96	0.54	0.28	1.76
40	33.27	32.05	6.23	12.52	3.19	2.27	0.55	0.41	1.88
High[3]	35.15	32.20	7.16	13.53	3.21	4.25	1.53	0.46	1.98
Low[3]	31.27	30.33	3.24	10.73	1.20	1.87	0.11	0.20	1.45
Difference .	3.88	1.87	3.92	2.80	2.01	2.38	1.42	0.26	0.53

[1] By phosphate method.
[2] By difference.
[3] Excluding 13 and 15.

Silica.—The highest and lowest figures (35.15 and 31.27 per cent) show a difference of 3.88 per cent. The high results are due in part to the neglect of

35 The Engineering and Mining Journal, February 21, 1903.
36 The Engineering and Mining Journal, December 14, 1901.

examining the purity of the silica after weighing; again, the slag may not have been sufficiently decomposed, or, after complete evaporation to dryness, silica may have re-combined with some of the bases insoluble in acid on account of overheating the residue. In regular furnace-work it is necessary to examine the silica with hydrofluoric acid to obtain a proof that the insoluble residue is silica. High results may also be due to insufficient ignition. In order to eliminate this error, it is necessary to ignite at least 10 minutes at the highest temperature of the blast-lamp. The low results can be ascribed only to neglecting to evaporate to dryness the filtrate of the residue which renders insoluble the silica that went into solution when the slag was being dissolved; often an additional 2 per cent silica may thus be obtained.[37] In the common method of working (evaporation to dryness and neglect of the silica that goes into solution) the high and low results are compensated to some extent.

Iron.—Between the highest and lowest results (33.20 and 30.33 per cent) there is a difference of 1.87 per cent. The sources of inaccuracy may be in the gelatinized silica occluding some iron, in the zinc used for reduction in the permanganate method not being free from iron, or in the iron of the substance used for standardizing the titrating solution (ferrous ammonium sulphate, iron wire) not having been accurately determined. The author distrusts the general applicability of the modifications of the permanganate method, permitting the use of hydrochloric acid as a solvent, and prefers the bichromate method, as no reagent need be used which is liable to affect the final result.

Alumina.—The results in the determination of alumina show large discrepancies; of 22 men reporting, only six obtained results that were approximately accurate. High results were obtained by the difference-method. The high figures are due to omitting the evaporation of the first solution and separating the silica, which was later on precipitated with the hydroxides of iron and alumina and weighed. A satisfactory rapid method for determining alumina has still to be worked out.

Lime.—Excluding No. 13, 60 per cent of the results are satisfactory from a metallurgical point of view, i.e., they agree within 0.25 per cent. The majority of the results were obtained by titrating with potassium permanganate; high results may be due to imperfect washing, low results to prolonged washing with boiling water or to insufficient standing before filtration.

Magnesia.—The majority of the results are satisfactory, i.e., accurate within 0.25 per cent. High figures may be due to insufficient washing, or igniting, or to the presence of silica; the low figures to incomplete precipitation or to a lack of ammonia. The precipitate must always stand for several hours before it may be filtered, but here ammonium chloride may have a solvent effect upon the glassware.

Zinc.—There is a difference of 2.38 per cent between the highest and the lowest results, and only six chemists give satisfactory results. In most cases

37 Hillebrand, *Journal* American Chemical Society, 1903.

the ferrocyanide method was used. The author rejects the use of this method in the presence of much iron and manganese, but has nothing better to suggest at present.

Manganese.—The results are unsatisfactory, the difference of 1.42 per cent being too large. The Volhard method is the one that was generally used. The author believes this to be accurate, and attributes these discrepancies to manganese and interfering elements in the zinc oxide and to the sodium carbonate used for neutralization.

Copper.—The difference of 0.26 per cent in the table is too large. So many methods were used that it is not possible to exactly point out the sources of error. The whole subject was discussed in THE ENGINEERING AND MINING JOURNAL, of October 18, 1901.

Sulphur.—The results are on the whole very satisfactory; the method used was oxidation with nitric acid and potassium chlorate, followed by precipitation with barium chloride.

Purchasing of Ores.—A. W. Warwick[38] publishes a paper entitled 'Ore-Sales' which covers a subject little discussed in technical papers. Selling ores to smelting plants means not simply cheap handling and freighting, and making a good contract with the smelter, but it often includes the right blending of ores to reduce the penalties in order that as high a return as possible may be obtained for the total product of the mine.

In blending ores, certain numbers of cars of different stopes can be dumped to form a lot for shipment; or, with small mines, certain grades of ore are stored and then united to make up a carload. Let a mine turn out five cars of ore at 20 tons a week, each of which can be shipped at a profit. Shipping each car separately would give the following values:

Car No.	Pb%	Zn%	Fe%	SiO_2 %	Gross Value Per Ton.	Treatment Penalties.	Net Value Per Ton.
1	4.2	7	18	60	$22	$9.20	$256
2	8.0	14	16	45	36	7.40	562
3	6.0	6	25	43	25	6.30	374
4	11.0	15	18	42	37	7.40	562
5	4.0	14	24	44	45	10.04	699
Net Value of Shipment.							$2463

Uniting the five lots gives 100 tons of ore (Pb 6.6 per cent; Zn 11.4 per cent; Fe 20.2 per cent; SiO_2 46.8 per cent) of a gross value of $33.00 per ton. With a treatment charge of $7.36 per ton, there would be left a net value of $25.64, or $2,564 for the 100 tons, and an extra profit of $101.

In some cases it may be advisable to make two lots instead of one, and so on. An article[39] entitled 'Settlements for Lead Ores' discusses some of the

38 *Mining Reporter*, February 19, 1903.
39 *Mining Reporter*, November 26, 1903.

inequalities experienced in the payments made by smelting plants for ores with two different percentages of lead.

S. S. Fowler[40] compares the returns received by the miner in British Columbia when he ships his ore to the United States, to have it smelted and refined, or sends it to England direct. His argument for preferring at present to send to England is made clear by the subjoined tabular statements:

SHIPPING TO THE UNITED STATES.

	Lead %	Gross Lead Content Per Ton of Ore. Lbs.	New York Price, less 20c. Per 100 lbs.	90% of total Value of Lead in Ore.	Freight and Treatment.	Duty 0.75c Per lb.	Net Value of Lead Per Ton of Ore.
1896	30.8	616	$2.78	$15.41	$22.50	$4.62	$11.71
Jan., 1897...	33.7	674	2.84	17.23	18.75	5.06	6.58
Dec., 1897...	33.7	674	3.50	21.23	18.75	10.11	7.63
						Duty 1.5c.	
1898	30.9	618	3.58	19.91	18.75	9.27	8.11
1899	46.4	932	4.27	35.82	20.00	13.98	1.84

SHIPPING TO ENGLAND.

	Lead %	Gross Lead Content Per Ton of Ore. Lbs.	Average London Price. Per Ton.	Equivalent in dollars, Less $1.00 Per 100 lbs.	90% of Total Value of Lead, Per Ton of Ore.	Freight and Treatment.	Net Value of Lead Per Ton of Ore.
1896	30.8	616	11- 3-9	$1.17	$7.86	$13.16	$5.30
Jan., 1897...	33.7	674	11-15-0	1.539	9.33	13.74	4.41
Dec., 1897 . .	33.7	674	12-12-6	1.728	10.49	13.74	3.25
1898	30.9	618	13- 0-0	1.809	10.06	13.18	3.16
1899	46.4	932	14-18-9	2.228	18.09	15.00	3.69

Importation of Base Bullion.—In the United States Circuit Court[41] at Trenton, N. J., a decision was rendered March 13th, in favor of the Guggenheim Smelting Company, the judge stating that the Dingley act having arbitrarily fixed base bullion of 90 per cent as the amount of refined lead to be obtained, no duty could be charged on the remaining 10 per cent. The Board of Appraisers and the Collector of Perth Amboy, N. J., had contended that the company was bound to export a quantity of refined metal equivalent in weight to the crude metal imported.

Wet Process.—C. Hoepfner[42] has patented a wet process for extracting lead and other metals from ores and mattes.

Smelting Lead Ores.

Lead-Smelting of Zinc-Gold Slimes in the Reverberatory Furnace.—Under this heading P. S. Tarverner[43] describes with illustrations the method of

40 *Canadian Mining Review*, June 30, 1903.

41 *Iron Age*, March 12, 1903, p. 13.

42 United States Patent No. 735,098, August 4, 1903.

43 *Journal* Chemical and Metallurgical Society of South Africa, 1902-03, Vol. III, pp. 70-77, 103-16, 121-123, 134-139; The Engineering and Mining Journal, January 24, 31, 1903.

smelting in a reverberatory furnace slimes at the works of the Bonanza Cyanide Works near Johannesburg, Transvaal. The slimes are obtained by precipitating from cyanide solutions by means of zinc-shavings; they consist of two parts, fine slime and fine zinc. The fine slime is passed through a filter-press, the resulting cakes are placed in trays, dried for 15 minutes in an oven, crushed to pass a 4-mesh sieve and mixed with fluxes. The fine zinc is allowed to drain for 30 minutes and then fluxed. The charge for slime is: slime, 100 parts; litharge, 60; saw-dust, 0.60; assay-slag, 10 to 15; foul slag, 10 to 15; silica, 5 to 10; with more than 60 parts of litharge from 0.9 to 0.12 parts of saw-dust are given. The charge for zinc is: fine zinc, 100 parts; litharge, 150; slag, 20. In fluxing slime, the 60 parts litharge may sometimes be reduced to 40; and with zinc, the 150 parts to 100, as long as enough base bullion is produced, viz., 12,000 oz. Trial charges made in crucibles will require 30 per cent more fluxes to obtain fusible slags than are necessary for regular work in the reverberatory furnace. The base bullion ought not to contain over 10 per cent gold; 8 per cent is a better figure.

The furnace has a hearth built into an iron pan; this is lined with a full course of fire-brick. The inside dimensions of the hearth are, length, 2 ft. 3 in.; width, 1 ft. 3.5 in.; it is inclined from fire- and flue-bridge toward the center, and from the back to the front; here is the tap-hole above which there is a charging-door, 4 in. above the level of the lead-bath. The grate is 9 in. wide. The hearth holds 12,000 oz. lead; the metal bath is 8 in. deep. The prepared charge is piled up in the center of the hearth, care being taken to prevent parts of it from coming in contact with the sides of the hearth; the piles receives now a covering of litharge over which is spread a light layer of readily fusible slag. On melting-day a slow fire is started at 3 A. M. to dry the charge; at 5 A. M. the fire is urged, and brought in about 30 minutes to a smelting-heat. By 9 or 10 o'clock the charge is completely melted, odds and ends from a former run are added, and finally some saw-dust given in order to reduce some lead from the slag which passing downward carries with it any precious metal from the slag into the bath of lead below. The fluid slag is now drawn into slag-pots of the Devereux type and tapped when settled. The slag tapped from the pots is a waste product, while the shells are re-smelted. The slag in direct contact with the lead has to be thickened with lime before it can be drawn. Any zinc present in the lead now burns off quickly, when the lead is tapped and run into bars to be cupelled.

The paper contains drawings of an old-fashioned English cupelling furnace; the manner of working is described in detail.

The advantages of this lead-smelting method over the usual acid treatment, followed by roasting and crucible-fusion, are cheapness and greater yield. At a comparative test with equal amounts of material at Crown Deep, the acid treatment cost 24c. per oz., lead smelting 6c.; the yield in gold in two trials was 10 and 11 per cent greater by smelting than by the combined wet and dry proeess. While these figures are exceptionally high, it may be stated that smelting always gives a better yield than acid treatment.

Roasting of Ores.—H. O. Hofman,[44] in a paper on the metallurgy of eopper of Montana, discusses with much detail the furnaees used in roasting, the operations and the results obtained. An abstract of the paper entitled 'Reeent Roasting Methods at Butte' has been published in THE ENGINEERING AND MINING JOURNAL, July 25, 1903, in whieh is reproduced a drawing of the Evans-Klepetko furnace.

E. J. Horwood[45] deseribes the roasting of slimes in heaps at the works of the Broken Hill Proprietary Company, Ltd. The slimes average: PbS, 24 per eent; ZnS, 29.40 per eent; FeS_2, 3.38 per cent; Fe_2O_3, 4.17 per cent; FeO (in garnets), 1.03 per eent; MnO (in garnets and rhodonite), 6.66 per cent; Al_2O_3, 5.40 per cent; CaO, 3.40 per eent; SiO_2, 22.98 per eent; Ag, 0.060 per eent; total, 100.48 per eent. Roasting in the meehanical furnaces used for sands made mueh dust; in addition the desulphurization is not any more satisfaetory, nor the eost any less than in eheap roasting. The slimes from the ore-dressing works are run from their bins in a semi-fluid eondition into railroad cars and dumped, after standing a while, along the side of the track. Later, when of the right eonsisteney, the plastic material is eut with shovels into brick-like blocks, and these, when sufficiently air-dried to permit handling, are loaded into ears and eonveyed to the heaps. In handling, about 10 per cent smalls are made. They are pugged with water and used as a eover for the heaps, a strip 5 feet wide along the erest being left uncovered. The heaps are 200 ft. long by 24 ft. wide by 7 ft. high. When heap-roasting was started the brieks were piled on a bed of wood in the usual way, the amount of wood required being 5 per eent on the ore. At present no bed-wood is used, but the flues left open, 12 ft. apart, along the floor, are enlarged near the sides of the heap, and wood is burnt in them. Less than 1 per eent wood is required to start the roasting. A heap is fully kindled in 24 hours. The roasting lasts two weeks; the roasted ore retains from 6.5 to 8.5 per eent sulphur. Temperature measurements showed that sintering began at about 800° C. The loss in lead is under 12.5 per eent, that of silver under 5 per eent. Roasting in stalls gave no better elimination of sulphur than did heaps, and the operation proved to be more expensive.

F. C. Roberts[46] patented an oblong gas-fired shaft furnaee for roasting ores. The furnaee has two rows of combustion chambers between which is a gas flue with its distributing pipes. From eaeh combustion chamber the flame passes through its ore ehamber and from this the gases pass into waste-gas ehambers and from these into the staeks. The ehambers have partition walls to permit a better regulation of stream of gas and of deseent of ore. Along the

44 *Transactions* American Institute Mining Engineers, February, 1903.
45 Australasian Institute of Mining Engineers, 1903, IX[1], pp. 106-116.
46 United States Patent No. 720,969, February 17, 1903.

top of a block of furnaces runs a track for the ore cars. From these the ore is dropped on to a roof-shaped distributor and delivered to the tops of the ore chambers. At the bottoms of these are converging chutes through which the roasted ore is discharged at intervals into a train of cars on the ground floor.

Huntington-Heberlein Process. At the meeting of the Broken Hill Proprietary Company, held July 31, 1903, the chairman, Mr. Harvey Patterson[47], referred in his report to the Huntington-Heberlein process[48] which had been installed the previous year and had worked satisfactorily since. The plant consists of 5 roasting furnaces and 17 converters. The process is also used by the Tasmanian Smelting Company.[49] Here the ore, a mixture of sulphate and oxide, averaging 10 per cent sulphur and mixed with the necessary lime, is dropped from a mechanical roasting furnace into the converter. This is a hop-

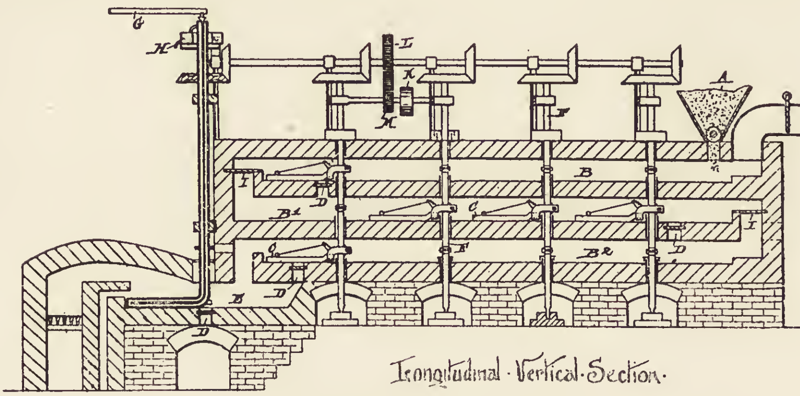

Fig. 3. Merton Roasting Furnace.

per-shaped sheet-iron cone, 5 ft. 6 in. in diameter and 6 ft. high, suspended by trunnions. The truncated apex is closed by a perforated plate forming the roof of a wind box. When the converter is filled, air under a pressure of 17 oz. per sq. in. is forced through the ore for from 2 to 4 hours, averaging 3 hours. The temperature at once rises and sulphur dioxide is given off; soon the ore mixture begins to soften and to agglomerate, when the converter is turned down and the contents dumped. The semi-fused ore retains about 1 per cent sulphur and is in an excellent condition to go to the blast furnace. The reactions involved are believed to be: At 700° C.: $CaO + O = CaO_2$. At 500° C.: $4\ CaO_2 + PbS = PbSO_4 + CaO$. Or $4\ CaO + PbS + O_4 = PbSO_4 + 4\ CaO$.

In the strongly oxidizing atmosphere of the converter, finally, the reaction $PbS + PbSO_4 + O_2 = PbO + 2\ SO_2$ is said to eliminate the sulphur. There are 12 converters at these works fed by two mechanical and two hand reverberatory roasting furnaces. It seems to be settled that not only lead sulphide, but

47 *The New Zealand Mines Record*, August 17, 1903.
48 The Mineral Industry, VII, p. 452; VIII, p. 399.
49 *Australian Mining Standard*, April 23, 1903.

also zinc, copper and iron sulphides will be oxidized when heated in contact with ($CaO + O$) formed during the preliminary heating; further, some evidence seems to show that ferrous and manganous oxides behave in a manner similar to that of calcium oxide.

In the Carmichael-Bradford[50] process, which resembles that of Huntington-Heberlein, raw sulphide ore is mixed with calcium sulphate, heated to 400° C., charged into a converter and then blown; the reaction taking place upon heating is believed to be $CaSO_4 + PbS = CaS + PbSO_4$; upon blowing, the calcium sulphide then is to be oxidized, and to furnish enough heat to agglomerate the roast and to drive off the sulphur. The difference between the two processes, as far as can be learned, is that Huntington-Heberlein start with a heated lime-ore mixture, while Carmichael-Bradford begin with a heated

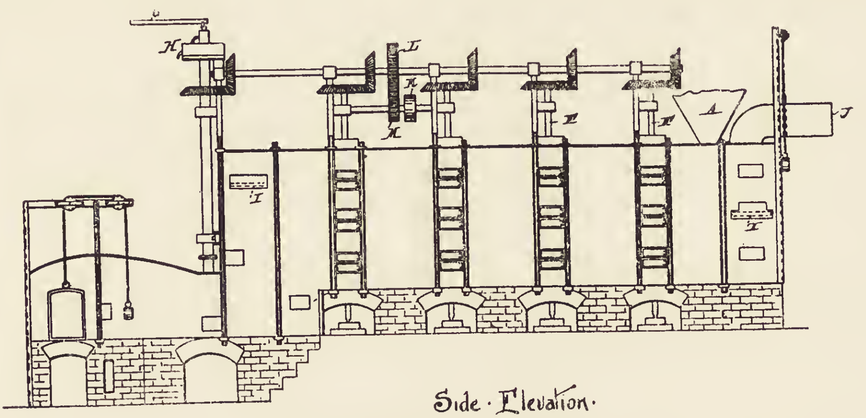

Fig. 4. Merton Roasting Furnace.

calcium sulphate-ore mixture; both blow in a similar converter in a similar manner and obtain an agglomerated product low in sulphur.

The Gross automatic and mechanically stirred desulphurizing furnace[51] put upon the market by the Colorado Iron Works, Denver, Col., is a turret or horseshoe-shaped mechanical roasting furnace with external fire-places, in which the annular hearth, carried by I-beams on trucks, moves, while the stirrers remain stationary. So far no facts have been published about the power required to move the hearth. A similar principle of having the hearth moving has been embodied in the straight-line furnace of the Ems lead works, Prussia.[52]

F. D. Power[53] gives an illustrated description of the Merton roasting furnace.[54] This is an oblong, straight-line, mechanical roasting furnace with three separate roasting hearths, B, B^1, B^2, and one finishing hearth E. The

50 See The Mineral Industry, XI, p. 440.
51 *Mining and Scientific Press*, August 29, 1903.
52 The Mineral Industry, XI, p. 439.
53 The Engineering and Mining Journal, November 21, 1903.
54 The Mineral Industry, XI, p. 441, 442.

ore fed mechanically at A is moved over the hearths by radial arms C, attached to vertical shafts F, driven by spur-and-pinion wheels. It drops from hearth to hearth through the slots D and cools in the vaulted chamber beneath the finishing hearth. The furnace is encased in ¼-in. iron plates and is braced with buckstaves and tie-rods. It is 32 ft. 9 in. long over all. The iron work weighs 12 tons; 10,000 red brick and 3,000 fire-brick are needed for the masonry work; between 1 and 2 h. p. are required for the stirrers. A roasting hearth has 4 doors on each side, situated opposite the stirring shafts; it is 23 ft. 9 in. long and 8 ft. high. In the center it is 1 ft. 4.5 in. high and at the

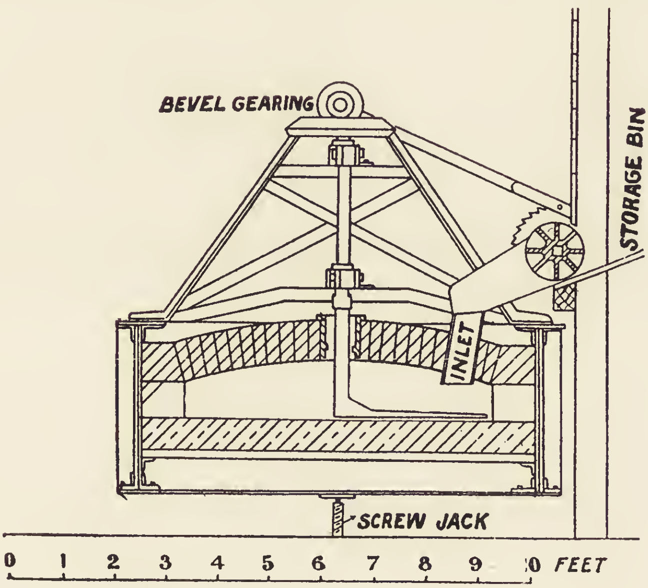

Fig. 5. Edwards Furnace. Receiving End.

sides 9 in. The thickness of the crown of the arch is 4.5 in. The finishing hearth has a working door on one side only. The vertical shafts are 4 ft. 3 in. apart from center to center and make from 1.5 to 2, or, for quick roasts, 3 revolutions per minute. The stirring arms attached to the shafts are 2 ft. 6 in. long. They are placed at right angles to one another in adjacent hearths, but in such a manner that three arms on a hearth point in the same direction. The blades slipped over the arms have varying forms. Some are plow-shaped, others are straight cast-iron plates placed at an angle to the arm. The finishing hearth has a separate water-cooled shaft and rabbling arm. As the rabbles on the roasting hearths have circular paths, it might be expected that dead corners would form in places not covered by them. Practice has, however, shown that the ore not touched by the plows or blades is displaced and moved on by the ore carried forward by each revolution of the arm. This, of course, pre-supposes that the ore shall show no tendency whatever to become sticky.

The following capacities for 24 hours are claimed for the furnace: Kalgoorlie sulpho-tellurides from 18 to 25 tons; blende-galena with Zn, 33 per cent; Pb, 19 per cent; S, 20 per cent, reducing the sulphur to 1.5 per cent, from 8 to 10 tons; pyrite from 6 to 15 tons depending upon the degree of desulphurization; copper sulphide, up to 10 tons; arsenopyrite from 5 to 8 tons; galena from 8 to 20 tons.

W. E. Simpson[55] describes with illustrations the Edwards and Merton furnaces. The Edwards furnace is a straight-line, single-hearth mechanical roasting furnace, 60 by 6 ft. The sides are made of iron girders and the ends of ¼-in. iron plate; heavy sheets of corrugated iron, bolted to the webs of the

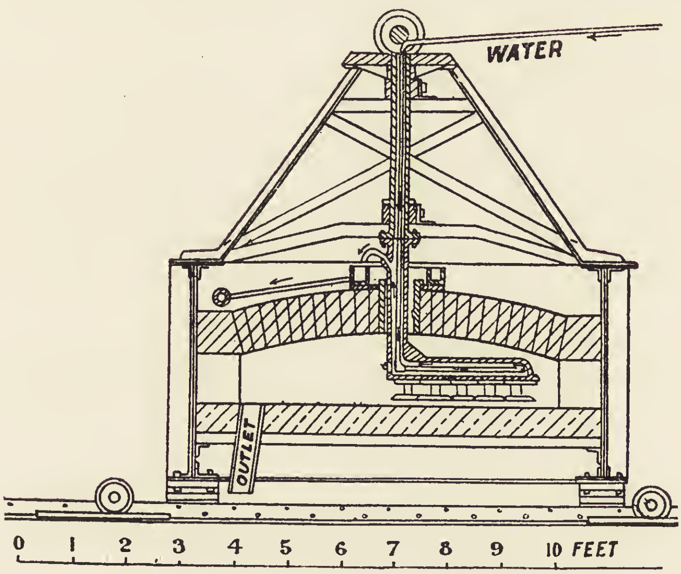

Fig. 6. Edwards Furnace. Discharge End.

girders, form the support for the furnace-floor. The frame is held about 2 ft. clear of the ground by pivots placed midway between the ends and kept at the required height by jackscrews; the inclination of the hearth is 9 in. in 60 ft. The ore delivered by a roller fed at one end is turned and moved forward to the discharge by 15 revolving rakes (see figures) attached to vertical shafts which pass through the roof and are held in position by iron frameworks. Each shaft moves in the opposite direction of its immediate neighbor, causing the rabbles to move the ore in a zig-zag course through the furnace. The ore charged to a depth of from 2 to 3 in. passes through the furnace in two hours.

An improved form of Edwards furnace has been put on the market by the Stearns Roger Mfg. Company, of Denver, Col.

Mr. Edwards[56] has patented a modification of his furnace which consists in

55 Institution of Mining and Metallurgy, October, 1903; The Engineering and Mining Journal, December 10, 1903.

56 United States Patent No. 725,056, April 14, 1903.

having the driving gear on the floor underneath the hearth instead of above it, as in his first furnace. This should be a decided improvement.

F. Klepetko[57] has modified the feed of the cooling water in his roasting kiln[58] in such a way as to make the central water feed pipe stationary and have the horizontal pipes, reaching into the stirrer-arms, rotate around it, as they are being moved over the hearths.

F. Klepetko[59] patented the idea of having an odd number, say, three, stirring arms on a hearth of a MacDougall or similar furnace. With two arms on a hearth the teeth are to be set in opposite directions so that they do not move the ore toward the periphery or the center, but simply stir it. The third arm is to move the ore. Thus the ore will be stirred more frequently than before, and will be moved downward at any speed desired, the advance being regulated by the position of the blades.

C. R. Repath and F. E. Marcy[60] aim to overcome the defect of the MacDougall furnaces, in which the ascending gas current traveling in a direction opposite to that of the ore carries with it the fines, by having the gases pass from a lower to an upper hearth in a vertical flue attached outside the cylinder. The ore in its descent from hearth to hearth is crowded alternately toward the inner and outer slot, and thus prevents the gases from ascending through the slots.

J. B. F. Herreshoff[61] patented an improvement in his well-known roasting furnace by means of which he crowds the ore towards funnels in the central and peripheral discharging openings and thereby forces the ascending gas current to pass around the funnels and not through them. In this way ore and gas travel in separate paths, and the gas will not carry along with it as much fine dust as it does with the old arrangement.

J. Roger[62] patented a water-cooling attachment to the Pearce turret furnace which is to protect from heat and corrosion that part of the stirring arm reaching into the furnace.

E. Swain and D. C. Wood[63] patented a straight-line, single-hearth, mechanical reverberatory roasting furnace in which there is provided a longitudinal wall some distance above and along either side of the hearth to carry the wheels of the truck supporting the rake-carrier. The reader of the patent is reminded of the longitudinal chamber of the Brown furnaces which is to protect the truck and wire rope from heat and gases. The protection has been overestimated, and here the chamber is cast aside; the tracks are laid on a shelf above the level of the ore.

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57 United States Patent No. 733,658, July 14, 1903.
58 The Mineral Industry, XI, p. 441.
59 United States Patent No. 744,359, November 17, 1903.
60 United States Patent No. 740,589, October 6, 1903.
61 United States Patent No. 729,170, May 26, 1903.
62 United States Patent No. 714,549, October 13, 1903.
63 United States Patent No. 734,104, July 21, 1903.

C. A. Fontaine[64] patented a mechanical, single-hearth, inclined reverberatory roasting furnace in which a rake-car provided with stirrers is run by gravity down the furnace and then picked up by an arm in an endless chain and returned to the head of the furnace.

R. von Zelenoski[65] patented a roasting furnace with swimming hearth.

C. A. Doremus[66] patented a circular, horizontally-rotating roasting furnace with stationary roof. The heat is furnished by gas burners placed radially, which deliver the flame on to the ore spread over the hearth. There is a special arrangement for sealing the joint the stationary roof makes with the revolving hearth; there are, further, openings for admitting air and carrying off roast gases, and for charging and discharging the ore.

Other patented roasting reverberatory furnaces are those of W. Harvey,[67] C. Cretors,[68] H. M. Sutton, W. L. Steele and E. G. Steele,[69] D. D. Bailey and J. O. Bailey[70] and A. M. Beam.[71]

R. Baggaley[72] covers with 26 patents all sorts of ideas from roasting through smelting and converting to dust catching.

F. Meyer[73] patented a muffle roasting furnace similar in general design to a MacDougall furnace. The furnace has five superimposed hearths. There are two blocks of furnaces each with five furnaces. A block has a fire-place on the ground floor to heat the floors and roofs and the bottom muffles. There is in addition a single fire-place for both blocks, the use of which is not made clear in the description.

The new roasting furnace of the National Automatic Furnace Company, Denver, Co.,[74] is a long revolving cylinder (similar to a White furnace) holding a cylinder of smaller diameter. The flame from a stationary fire-place travels between the two cylinders and heats the ore which is being conveyed by a mechanical device in a direction opposite to that of the flame. The furnace is intended for heating the ore to from 400 to 600° C., *i. e.,* to subject it to a mildly oxidizing roast. Two of these furnaces have been erected at Eureka, Ore., for the Eureka Mining, Smelting & Power Company to give copper and gold-bearing ores a sulphatizing roast that they may be freed from copper and then leached with potassium cyanide.

G. T. Rendall[75] patented a mechanical muffle roasting furnace consisting of an externally heated iron cylinder through which the ore is made to travel by means of conveyors.

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64 United States Patent No. 739,485, September 22, 1903.
65 United States Patent No. 741,430, October 13, 1903.
66 United States Patent No. 723,251, March 24, 1903.
67 United States Patent No. 727,540, May 5, 1903.
68 United States Patent No. 728,549, May 10, 1903.
69 United States Patent No. 729,008 and 729,009, May 26, 1903.
70 United States Patent No. 744,992, November 24, 1903.
71 United States Patent No. 745,765, December 1, 1903.
72 United States Patent Nos. 746,235-746,261, December 8, 1903.
73 United States Patent No. 731,144, June 16, 1903.
74 *Mining Reporter*, January 1, 1903.
75 United States Patent No. 724,942, April 7, 1903.

Oil as Fuel.—S. E. Bretherton[76] states that in 1888 the plant of the American Smelting Works at Leadville, Col., was the first to use residuum from Florence (Col.) petroleum as fuel for boilers. Later on it was used in roasting furnaces.

Blast Furnace.—F. B. Pettingill and E. Nicholson[77] patented a smelting furnace consisting of an oil-combustion chamber attached to a vertical smelting hearth, lined alternately with water tubes and fire brick.

P. Danckwardt[78] patented a flat-bottom slag pot of peculiar form, which permits removal of bottom and of front.

W. E. Koch[79] patented a blast furnace with dust chamber attached to it. The dust is to be mechanically conveyed into a fritting furnace which resembles very much a gas producer.

Mechanical Feeding of Blast Furnaces.—H. M. Hixon[80] in discussing A. S. Dwight's paper[81] on this subject states that the curtain and spreader of the mechanical feeder adopted at East Helena is nothing else than the Pfort curtain. In this he is mistaken; as with the curtain[82] the charge is introduced in the middle of the furnace, when the coarse parts have a tendency to roll toward the sides; while Dwight aims to deliver the charge at the sides, when most of the coarse parts will roll toward the center and the fines remain near the walls.

Cooling of Water.—E. A. Uehling[83] has constructed a spray nozzle of gun metal, called Simplex, which serves for the overflow water of water jackets or bosh plates. The hot water from the furnace is conducted through a main to receive a head of from 10 to 15 ft., which delivers it into a number of horizontal pipes spaced over a reservoir. Each of these pipes has on the upper side two spray nozzles. A nozzle has the form of an inverted hollow cone, in the opposite sides of which are two holes set at such an angle that the streams of water passing through them striking one another are broken up with a fine spray. The method of cooling appears to be very simple and effective, the only drawback being perhaps that the holes may become clogged from the scum that often forms with cooling water that is being used over and over.

Blast Furnace Work.—Birnbaum[84] publishes some facts about the work of the new blast furnace at the smelting and refining works of Tarnowitz, Silesia. The total height of the furnace is 28.96 ft., the diameter at tuyere level 7.87 ft. There are 15 tuyeres placed in two rows. From November 1 to 16, 1903, the furnace put through in 24 hours 251.98 tons charge with 21.188 tons of coke,

76 *Mining and Scientific Press*, January 10, 1903.
77 United States Patent No. 718,726, January 20, 1903.
78 United States Patent No. 721,288, February 24, 1903.
79 United States Patent No. 732,014, June 30, 1903.
80 THE ENGINEERING AND MINING JOURNAL, February 14, 1903.
81 THE MINERAL INDUSTRY, XI, pp. 442-444.
82 Hofman, 'The Metallurgy of Lead,' 1899, p. 234.
83 *Ircn Trade Review*, February 19, 1903.
84 *Berg- und Huttenmannische Zeitung*, 1903, p. 611.

or a total of 272.486 tons material, and produced 94.799 tons base bullion, the blast pressure ranging from 26.7 to 28.3 in. water. Of the slag assays made, 82 gave under 1 per cent Pb; 71 from 0.30 to 0.70 per cent; 11 from 0.75 to 1.00 per cent; 14 from 1.05 to 1.65 per cent. The author believes that the smelting power has not reached its maximum, but will increase to 325 tons material in 24 hours.

Hot Blast.—S. E. Bretherton[85] in giving his experiences in the elimination of arsenic, antimony, lead and zinc from copper mattes in smelting with the use of hot blast, records some trials in smelting galena with heated blast. So far the tests have proved to him that warm blast can be employed in treating lead ores in the blast furnace with a considerable saving of fuel, provided care be taken to have a good reduction. More experiments will have to be carried out before any reliable data can be had.

Zinc in Lead Slags.—W. M. Hutchings[86] states his belief that in slags not too basic zinc oxide is present mainly, if not wholly, as silicate. On one occasion he found in his blast furnace slags willemite, embedded through the mass (an iron-olivine fayalite) and free in cavities. The same slag contained magnetite combined with a considerable amount of zinc oxide. Such magnetite treated with strong nitric acid left behind shells of material rich in zinc oxide (intercrystallized zinc-iron spinel). Referring to a former paper on this subject,[87] the author thinks there is good ground for believing that all the zinc oxide is slagged off at first and that later in cooling some zinc oxide separates out in forms ranging from zinkiferous magnetite to a more or less impure zinc-iron spinel.

Cleaning of Slags.—Vambera,[88] who a few years ago[89] studied the phenomena involved in the settling of matte, now takes up the cleansing of slags which are made rich by particles of matte being held in suspension or solution. In tapping periodically matte and slag together from the blast furnace, some matte is oxidized which, acting upon sulphide, causes gases to be set free. These as well as the gases held in solution by the melted masses in the furnace, but set free when leaving it, disturb the settling of the matte and thereby enrich the slag.

As it is impracticable to prevent oxidation, when matte and slag pass over the slag spout, the author tried to find what effect solidification in the slag pot under a layer of glowing charcoal might have. For this purpose he filled five slag pots from one of the Przibram lead blast furnaces, three of which were covered with glowing charcoal. Pots Nos. 1, 3 and 5, with the charcoal cover solidified quarter of an hour later than pots Nos. 2 and 4, which cooled in the usual way. Samples taken from tops and centers of the slag cones

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85 *Transactions* American Institute of Mining Engineers, 1903, XXXIV.
86 The Engineering and Mining Journal, December 24, 1903.
87 *Geological Magazine*, January, 1890.
88 *Oesterreische Jahrbuch*, 1903, LI, 135-158.
89 The Mineral Industry, IX, 451.

showed no appreciable differences in their contents of silver, lead and sulphur. The reducing effect of the glowing charcoal upon the matte-content of the slag is therefore too weak to have any practical value.

Re-smelting the slag with or without the addition of reducing agents may have the desired effect. As fusions in Hessian crucibles gave unsatisfactory results, graphite crucibles were used, the carbon of which acted upon the slag. Experiments carried out with two slags gave enriched products resembling speiss and matte.

Materials.	Sp Gr.	Fe %	Ag %	Pb %	S %	Cu %
Poor Slag.						
Before re-melting..........	3.632	20.7	0.001	0.2	1.04	n. d.
After re-melting..........	3.054	15.1	0.000	0.08	0.33	n. d.
Speiss......................	6.250	88.9	0.006	0.10	0.39	n. d.
Rich Slag.						
Before re-melting..........	3.829	20.3	0.019	5.41	2.70	0.27
After re-melting...........	2.985	14.5	0.001	0.12	0.25	0.04
Matte.......................	6.102	74.0	0.140	0.14	5.40	2.20

The experiments show that values can be recovered by re-smelting. Thus at Freiberg, Saxony, it is the regular practice to re-treat the blast furnace slags at least once.

In smelting with a furnace having an Arents siphon tap, the richness of the slag will vary to some extent with the amount of matte that comes out with the slag. Therefore furnace men raise or lower the level of the lead in the furnace and keep the pots of slag obtained when the lead was high separate from those when it was low. The author thinks that with the Mathewson fore-hearth[90] oxidation of matte would be avoided and thus a cleaner slag obtained, but believes that the water-cooled tymp has been the cause of its not being much used now, and suggests a fore-hearth similar to that of the Krigar cupola. The reason that the Mathewson fore-hearth is not used at present in Colorado is that the ore charges contain very much zinc. This forms a light mushy matte which floats upon the heavy fluid matte and causes trouble in tapping. Even in the Iles fore-hearth, where it is used to clean slags, there is a separate tap-hole through which this mushy matte has to be coaxed, as letting it pass through the regular matte tap causes trouble.

Desilverizing Matte.—F. R. Carpenter[91] patented a process and apparatus for desilverizing silver and gold-bearing iron matte by means of lead. He brings melted matte and lead together and subjects the matte to an oxidizing fusion.

Flue Dust.—F. Cazin and L. J. W. Jones[92] patented a dust chamber of rectangular cross-section having a number of longitudinal partitions slightly raised from the horizontal. The dust-laden gases enter the chamber at one end, expand in it and, passing over the approximately horizontal division

90 Hofman, 'The Metallurgy of Lead,' 1899, p. 238.
91 United States Patent Nos. 718,088 and 718,089, January 13, 1903.
92 United States Patent No. 734,818, July 28, 1903.

planes drop their dust and leave at the opposite end. In the side walls are several doors to permit raking out the dust that has settled. In the Freudenberg system[93] we have plates suspended in the direction of the draft; here we have them supported in an approximately horizontal position.

F. A. Pascoe[94] patented a smoke and fume condenser.

E. J. McAleer[95] patented a washing apparatus for blast furnace gases in order to free them from dust.

Briquetting.—A method of briquetting iron ores followed by roasting the briquettes practiced in Pitkaranta, Sweden,[96] is of interest to lead smelters in handling fine ore and flue dust. The briquetting machine is a 2-stamp battery which makes per hour from 1,200 to 1,500 briquettes 6 by 5 by 2.5 in. and requires a 3-h.p. engine. The briquettes are roasted in a flue 152.5 ft. long by 7.5 ft. high by 6 ft. wide. Briquettes to the number of 480 are piled up in flat cars, 3.3 ft. long, in such a way as to leave only a small free space between roof and pile. The cars have flanges on the sides which, fitting into grooves filled with sand, make an air-tight joint. In the flue three divisions may be distinguished: The head division, 60.6 ft. long, at which the cars loaded with green briquettes enter and in which the briquettes are warmed; the central division, 34.4 ft. long, in which the briquettes are roasted by being heated with producer gas; and the tail-division, 57.4 ft. long, in which the roasted briquettes are cooled and at the end of which the cars leave the flue. The air for combustion enters at the head end, underneath the platforms of the cars, travels through the flue-cooling the bottoms of the cars, rises at the tail end into the compartment above the platforms of the cars, travels over the ore and meets, after having been thus pre-heated, the producer gas. The products of combustion pass over the green briquettes, giving off to them some of their heat before passsing off into the stack placed near the head end.

A train of about 14 cars is moved the length of 1 car every 50 minutes by winding up on a windlass at the tail end a chain which, resting on rollers fixed to the floor, is hooked to the last car at the head end. When a car of roasted and cooled briquettes at the tail end has been removed from the flue, the chain is unhooked and pulled back again into its first position, by means of a windlass and small chain at the head end, and hooked to the car with green briquettes, which has been moved in the meantime into the flue.

E. B. A. Zevoyer[97] patented a briquetting machine based on a principle similar to that of the Fouquemberg machine. It has a pair of rolls with cavities in the surface which, meeting, will compress the pulverulent material, charged from above, to a briquette which it discharges beneath.

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93 Hofman, 'Metallurgy of Lead,' 1899, p. 389.

94 United States Patent No. 746,989, December 15, 1903.

95 United States Patent No. 725,352, April 14, 1903.

96 T. Magnusson, *Jernkontorets Annaler*, 1902, p. 255; *Oesterreische Zeitschrift fur Berg- und Huttenwesen*, 1903, p. 180.

97 United States Patent No. 718,043, January 6, 1903.

Desilverization of Base Bullion.

Parkes Process.—F. L. Piddington[98] describes in outline the Parkes process as carried out at the works of the Smelting Company of Australia. These works treat 200 tons base bullion a week in a double set of 15-ton furnaces. In softening, the dross is drawn into slag pots having a hole some 4 ins. above the bottom to drain off lead. The dross contains from 65 to 70% Pb and from 2 to 9% Cu, averaging 4% Cu. An analysis of antimony skimmings gave PbO, 78.11%; SbO_2 (?), 8.75%; As_2O_3 (?), 2.18%; CuO, 0.36%; CaO, 1.10%; Fe_2O_3, 0.42%; Al_2O_3, 0.87%; insoluble, 4.10%. The lime in the skimmings comes from the practice of charging slacked lime before drawing to stiffen the fluid skimmings. The desilverizing kettles hold from 12 to 13 tons softened bullion. In ordinary work they are filled with 11 tons. When filled from the softening furnace the lead is cooled to near freezing in order to permit removing the coppery dross that rises to the surface and thus hastens the subsequent zinking. With 11-ton charges and making separate gold and silver crusts, 1 lb. zinc takes out the following quantities of gold and silver:

In the Gold Crust.		In the Silver Crust.	
With Ounces Gold in kettle.	Ounces Gold.	With Ounces Silver in kettle.	Ounces Silver.
300	1.80	1,450	5.6
200	1.00	1,200	4.1
150	0.79	930	3.8
100	0.59	755	3.5
60	0.45	{ 616	3.4
		{ 460	2.6

In taking off gold and silver together, 1 lb. zinc takes out the following quantities:

With Ounces in Kettle.		Ounces.	
Gold.	Silver.	Gold.	Silver.
494	3,110	0.59	3.60
443	1,883(?)	0.64	2.80
330	2,417	0.45	3.34
204	1,638	0.36	2.86
143	1,330	0.28	2.65
123	1,320	0.23	2.54

The tables show that the weight of zinc required increases faster than the precious metal extracted, or rich lead required more zinc for desilverization than poor lead. The present practice is to take off gold and silver as a gold-silver-zinc-lead crust. For this purpose, 250 lb. zinc are given at the start, whatever the tenor of gold and silver, thereby saturating the lead with from

98 *Journal* Chemical and Metallurgical Society of South Africa, 1903, III, pp. 207-210; *Canadian Mining Review*, July 31, 1903; The Engineering and Mining Journal, October 3, 1903; *Berg- und Hüttenmännische Zeitung*, 1903, p. 592.

0.6 to 0.7% Pb, any excess combining with precious metal, and to make two further additions to clean the kettle. An average of 237 charges gave the following figures, the first addition being 250 lb. zinc, the second 127 lb. and the third 57 lb.:

Total Ounces in Kettle.		Zinc Used.	One Pound Zinc Took Out. Ounces.	
Gold.	Silver.	Pounds.	Gold.	Silver.
520	1,186	407.5	1.27	2.91

In 12 cases out of the 237, no third addition was necessary, showing that the second or main crust was not saturated.

The desilverized lead is siphoned off into a poling kettle and refined with steam. Heating up lasts 4 hours, steaming from 3 to 4 hours, the dry steam being passed in through a ¾-in. pipe. A kettle is good for about 60 charges. A peculiarity of the mode of operating is to stir the lead and to feed in wood from time to time while the steaming is going on, the reasons for this procedure being to prevent the excessive formation of lead oxide. Ordinarily the amount of lead oxidized varies indirectly as the temperature. If the temperature is a little too low, you can steam and steam, and the lead will not become soft; if the temperature is too high there is danger of the bottom of the kettle suffering. An hour or so after removing the oxides from the refined lead this will be cool enough for molding.

The zinc crusts are liquated in a reverberating furnace having a trough-shaped, inclined (¾ in. to 1 ft.) hearth made of cast iron; the sides are turned up 4 in.; the whole rests upon a bed of brasque. The dry crusts are retorted in a Faber-du-Faur furnace. A retort (class 409 Battersea) holds 560 lb. of crust and lasts 30 charges. The condenser is a sheet iron (⅛ in.) cylinder, 12 in. in diameter, lined with a mixture of lime, clay and cement. It has three openings, one on top near the neck of the retort to permit poking the charge, one near the opposite end for the exit of the gases, and a tap hole. When a distillation is finished, the condenser is removed and the retort bullion (7% of charge by weight) skimmed and poured into bars. The dross goes to a cupelling furnace or to a softening furnace, after the skimmings have been taken off, to be freed from most of its precious metal. The partly desilverized dross then goes to the blast furnace. The zinc recovered amounts to 60% of that originally used. The blue powder formed is sifted to remove scraps of metallic zinc, and goes either to the blast furnace or is sold to cyanide plants to be used as a precipitant. The retort bullion, together with the bullion obtained in desilverizing retort dross, is concentrated in one cupelling furnace to 50 or 60% silver and finished in another. The doré silver obtained is 995 fine. The concentrating hearth has been lined with different proportions of limestone, cement, fire clay and magnesite. Ordinarily a mixture of sand and cement is used. The sides of the concentrating furnace are either cooled by a 1-inch water pipe imbedded in the hearth material, or by means of a water jacket, the inner face of which is of copper;[99] the front is closed by a water jacket. The refining test has no water-cooling devices. The doré silver is melted in 2,000 oz. plumbago crucibles.

A patent[100] has been granted to W. H. Howard for his improved form of alloy press.[101]

In distilling zinc ores in the Silesian muffle, Kiessling[102] found that by the addition of 0.5% sodium chloride to the charge, the amount of oxide and blue powder formed was reduced one-half. A similar addition to the retort charge in distilling zinc crusts may be worth a trial.

Electrolytic Refining, Betts Process.—A. G. Betts[103] describes his process of electrolytic refining lead at Trail, B. C., in which lead-fluosilicate serves as electrolyte, base bullion cast in sheets as anodes and electrolytically deposited films of lead as cathodes. An outline of T. Ulke's description[104] of this plant was published last year.[105] The following data supplement the former record:

Lead fluosilicate readily crystallizes with four molecules of water, $PbSiF_6 + 4H_2O$, the crystals resemble those of lead nitrate. The salt dissolves at 15° C. in 28 per cent of its weight of water, making a syrupy solution (sp. gr. 2.38); at 60° C. it melts in its water of crystallization. A neutral solution of the salt is partly decomposed upon heating, being split into a basic insoluble salt and free acid; the decomposition stops, however, when about 2% of acid have been set free. The salt can then be evaporated without further decomposition. The electric conductivity depends mainly upon the amount of free acid present. When used as an electrolyte without the addition of a reducing agent (gelatine or glue) the cathode deposit lacks solidity, and branches of lead grow toward the anode and cause short-circuiting. With the addition of gelatine the cathode-lead is dense (sp. gr. 11.36, equal that of cast lead).

The electrolyte originally used contained 6% Pb and 15% SiF_6; an analysis later on gave Pb, 0.07%; Sb, 0.0192%; FeO, 0.24900%; SiF_6; As trace; there was little short-circuiting. In starting a new plant hydrofluoric acid of 35% HF is run into a series of tanks, in the first of which is placed a layer of quartz 2 ft. thick; the second is charged with white lead in the required amount. All hydrofluoric and sulphuric acid not acted upon by the silica and lead carbonate settles out as lead sulphate and fluoride. The electrolyte is filtered and run into the electrolyzing vats. These resemble the tanks used in an electrolytic copper refinery using the multiple process; they are 86 in.

99 THE MINERAL INDUSTRY, X, p. 434.

100 United States Patent No. 739,003, September 15, 1903.

101 THE MINERAL INDUSTRY, IX, p. 451.

102 *Berg- und Hüttenmännische Zeitung*, 1903, p. 613.

103 *Transactions* American Institute Mining Engineers, 1903, XXXIV; *Canadian Mining Review*, 1903, p. 153; *Mining and Scientific Press*, February 28, 1903.

104 THE ENGINEERING AND MINING JOURNAL, October 11, 1902.

105 THE MINERAL INDUSTRY, XI, p. 453.

long by 30 in. wide by 42-in. deep, are made of 2-in. cedar planks bolted together and coated with rubber paint. A tank is charged with 22 anodes (total weight, 3 tons, immersed area of each, 26 by 33 in.) and 23 cathodes ($^1/_{16}$ in. thick, deposited on lead-plated and paraffined iron cathodes suspended from copper bars 0.5 by 1 in.). An anode is corroded in from 8 to 10 days; the cathodes are replaced every 4 or 5 days. The purity of the cathode lead is proportional to the smoothness of the deposit. Impurities in the deposited lead seem to be due mainly to floating particles of slime attaching themselves to it; these in their turn appear to take more current and cause the formation of lumps. Lumpy parts of a cathode, for example, gave upon assaying from 1 to 2.5 oz. silver per ton, smooth parts only, 0.04 oz., while the average assay of a deposited sheet was 0.25 oz.

A tank with 4,000 amperes passing through it yields 750 lb. lead per day. With a current of 2,800 amperes the fall in potential per tank was found in one instance to be 0.44 volts. (The usual figure is 0.35 volts.) This high figure was found to be due mainly to the thickness of the anode slime, which with impure bullion may become 0.5 in. thick. This impedes the free circulation of the electrolyte near the anode, causing it to become saturated with lead and neutralized. For this reason the anodes are cast thin and are removed with most of the slime adhering to them and cleaned in separate tanks. The 28 tanks of the plant make 8 to 10 cu. ft. of anode mud, of which 90% by volume is electrolyte. As the amount of water evaporated in the tanks is about 15 cu. ft. per day, only a limited quantity of wash water may be used. The mud is stirred up several times with ordinary electrolyte and allowed to settle that it may be compacted before any wash water is used.

In the process, gold, silver, copper, antimony, arsenic and bismuth go into the anode mud, while tin, iron, zinc, nickel and cobalt go into solution. Tin and lead have about the same electromotive forces of solution; hence any small amounts of tin present have first to be removed, *e. g.*, by poling giving drosses (see table I); large amounts would require a special softening operation. Iron appears to remain mainly in the anode mud; this is due probably to its being present in the base bullion in combination with sulphur. In order to purify a fouled solution, the lead will be precipitated with sulphuric acid and the hydrofluoric acid with sodium chloride, as sodium-fluosilicate. From this compound the hydrofluoric acid can be recovered with one-third the amount of sulphuric acid required by calcium fluoride. The anode mud is worked up in a manner similar to that of an electrolytic copper refining plant. The author calculates the cost of the process as follows: Five amperes in 24 hours produce 1 lb. of lead per tank. One ton of lead equals 10,000 ampere days, and at 0.35 volts per tank, 3,500 watt-days or 4.7 e. h. p. days. Allowing 10 per cent loss of efficiency in tanks, and 8% in generator, increases the 4.7 to about 5.6 e. h. p. days; with a further allowance for the electric lights and other applications there is a further increase to from 7 to 8 e. h. p. days, as about the amount per ton of lead. At $30 per year this item of cost is something like $0.65 per ton of lead. The cost of labor is not greater than in the zinc-desilverizing process. The following tables give analyses of the raw materials used and the products obtained in operations carried on in the works and in the experimental laboratory:

A. WORKS ANALYSES.

TABLE I.—DROSSES. (4 PER CENT ON LEAD.)

No. of Lead in Table II.	Cu %	As %	Sb %	Fe %	Zn %
2	0.0005	0.0003	0.0016	0.0016	None.
3	0.0010	0.0008	0.0107	0.0011	"

TABLE II.—ANALYSES OF BASE BULLION.

No.	Fe %	Cu %	Sb %	Su %	As %	Ag %	Au %	Pb %	Ag oz. p. ton	Au oz. p.ton
1	0.0075	0.1700	0.5400	0.0118	0.1460	1.0962	0.0085	98.0200	319.7	2.49
2	0.0115	0.1500	0.6100	0.0158	0.0960	1.2014	0.0086	97.9068	350.4	2.52
3	0.0070	0.1600	0.4000	0.0474	0.1330	1.0738	0.0123	98.1665	313.2	3.60
4	0.0165	0.1400	0.7000	0.0236	0.3120	0.8914	0.0151	97.9014	260.0	4.42
5	0.0120	0.1400	0.8700	0.0432	0.2260	0.6082	0.0124	98.0882	177.4	3.63
6	0.0055	0.1300	0.7300	0.0316	0.1030	0.6600	0.0106	98.2693	192.5	3.10
7	0.0380	0.3600	0.4030	......	Trace.	0.7230	0.0180	98.4580	210.9	5.25

TABLE III.—ANALYSES OF SLIMES.

Fe %	Cu %	Sb %	Su %	As %	Pb %	Zn %	Bi %
1.27	8.83	27.10	12.42	28.15	17.05	None.	None.
1.12	22.36	21.16	5.40	23.05	10.62	"	"

TABLE IV.—ANALYSES OF REFINED LEAD.

No.	Cu %	As %	Sb %	Fe %	Zn %	Sn %	Ag oz.p.ton.	NiCoCd %	Bi %
1	0.0006	0.0008	0.0005	.....	.....	.....	.....	.....	.....
2	0.0003	0.0002	0.0010	0.0010	None.	.....	.....	.....	.....
3	0.0009	0.0001	0.0009	0.0008	"	.....	0.24	.....	.....
4	0.0016	.....	0.0017	0.0014	.....	.....	0.47	None.	.....
5	0.0003	.....	0.0060	0.0003	.....	.....	0.22	.....	.....
6	0.0020	.....	0.0010	0.0046	.....	.....	0.22	None.	.....
7	0.0004	None.	0.0066	0.0013	None.	0.0035	0.14	.....	.....
8	0.0004	.....	0.0038	0.0004	"	0.0035	0.25	.....	.....
9	0.0005	.....	0.0052	0.0004	"	0.0039	0.28	.....	.....
10	0.0003	None.	0.0060	0.0003	"	0.0049	0.43	.....	.....
11	0.0003	"	0.0042	0.0013	"	0.0059	0.32	.....	.....
12	0.0005	"	0.0055	0.0009	"	0.0049	0.22	.....	.....
13	0.0005	"	0.0055	0.0007	"	0.0091	0.11	.....	.....
14	0.0004	"	0.0063	0.0005	"	0.0012	0.14	.....	.....
15	0.0003	"	0.0072	0.0003	"	0.0024	0.24	.....	.....
16	0.0006	"	0.0062	0.0012	"	0.0083	0.22	.....	.....
17	0.0006	"	0.0072	0.0011	.....	0.0080	0.23	.....	.....
18	0.0006	"	0.0057	0.0010	.....	0.0053	0.34	.....	.....
19	0.0005	"	0.0066	0.0016	.....	0.0140	0.38	.....	.....
"	0.0005	"	0.0044	0.0011	.....	0.0108	0.35	.....	.....
20	0.0004	"	0.0047	0.0015	.....	0.0072	0.22	.....	.....
"	0.0004	"	0.0034	0.0016	.....	Trace.	0.23	.....	.....
21	0.0022	"	0.0010	0.0046	None.	0.0	0.38	None.	None.

B. LABORATORY EXPERIMENT ANALYSES.

TABLE V.—ANALYSES BASE BULLION AND REFINED LEAD.

Material.	Ag %	Cu %	Sb %	Pb %
Base Bullion	0.50	0.31	0.43	98.76
Refined Lead.	0.0003	0.0007	0.0019	99.9971

TABLE VI.—ANALYSES BASE BULLION AND REFINED LEAD.

Material.	Cu %	Bi %	As %	Sb %	Ag oz.p.ton.	Ag %	Au oz.p.ton.	Fe %	Zn %
Base Bullion	0.75	1.22	0.936	0.6832	358.89	. . . . . .	1.71	. . . . . .	. . . . . .
Refined Lead. . . .	0.0027	0.0037	0.0025	0.0000	. . . . . .	0.0010	None.	0.0022	0.0018

TABLE VII.—ANALYSES BASE BULLION, REFINED LEAD AND SLIMES.

Material.	Pb %	Cu %	As %	Sb %	Ag oz.p.ton.	Ag %	Fe Zn Ni Co %	Bi %
Base Bullion.	96.73	0.096	0.85	1.42	275	. . . . . .	. . . . . .	. . . . . .
Refined Lead.	. . . . . .	0.0013	0.00506	0.0028	. . . . . .	0.00068	0.0027	Trace.
Slimes	9.05	1.9	9.14	29.51	9366.9	. . . . . .	0.49	"
Base Bullion.	87.14	1.40	7.4	4.0	. . . .	0.64	. . . .	0.14
Refined Lead	. . . .	0.0010	Trace.	0.0017	. . . .	. . . .	. . . .	0.0022
Slimes	10.3	9.3	44.58	25.32	. . . .	4.7	. . . .	0.52

MANGANESE.

The production of manganese ores of all grades in the United States is shown in the subjoined table. The statistics do not cover the output of manganiferous iron ores in Colorado and other Western States which is consumed as a flux in silver-lead smelting, account being taken only of that portion which enters into the manufacture of ferromanganese and spiegeleisen.

STATISTICS OF MANGANESE ORE IN THE UNITED STATES. (IN TONS OF 2,240 LB.)

Year.	Production.										
	Arkansas.	California.	Colorado.	Georgia.	Michigan and Wisconsin.	New Jersey.	Tennessee.	Virginia.	Elsewhere	Totals. Tons.	Totals. Value.
					(a)	(b)					
1899...	855	263	29,161	1,623	53,702	53,921	30	3,626	7	143,256	$306,476
1900...	51	231	45,791	1,053	75,360	91,748	*Nil.*	3,988	....	218,222	461,994
1901...	91	610	62,385	4,076	512,084	52,311	400	4,275	2,565	638,795	1,644,117
1902 (c)	82	846	13,275	3,500	884,939	65,246	*Nil.*	6,041	8	973,937	2,127,783
1903 (c)	*Nil.*	16	14,856	500	566,835	73,264	*Nil.*	1,801	508	660,582	1,670,349

(*a*) Manganiferous iron ore. (*b*) Franklinite residuum. (*c*) Statistics of U. S. Geological Survey.

Year.	Imports.		Consumption.	
	Tons.	Value.	Tons.	Value.
1899...	188,349	$1,584,528	331,605	$1,891,004
1900...	256,252	2,042,361	474,474	2,504,355
1901...	165,722	1,486,573	804,517	3,130,690
1902...	235,576	1,931,982	1,208,513	4,059,765
1903...	146,056	1,278,108	806,638	2,948,457

In the following table the production of manganese ores in the different States is distributed according to the relative percentages of metallic manganese, and the total production, imports and consumption are given in terms of ore containing 50 per cent manganese. It will be observed that the output of high-grade ore in this country constitutes only a small proportion of the quantity consumed each year, the greater part of the supply being drawn from foreign sources, chiefly Brazil, Russia and Cuba.

MANGANESE PRODUCTION AND CONSUMPTION OF THE UNITED STATES ON A BASIS OF 50% MN CONTENT. (IN TONS OF 2,240 LB.)

Year.	50% Ores from Ark., Ga., Va., Cal., Tenn., etc.	30% Ore from Colorado.	12% Ore from NewJersey.	7% Ore from Mich. and Wisconsin.	Equivalent Total Tonnage of 50% Ore.	Imported Ores of 50% Grade	Total Consumption of 50% Grade & Equivalent.	Per Cent of Import'd Ore.
1899..	6,397	29,161	53,921	53,702	44,353	188,349	232,702	80.1
1900..	5,323	45,791	91,748	75,360	65,368	256,252	321,620	79.7
1901..	9,450	62,385	52,311	512,084	*a*131,127	165,722	296,849	55.8
1902*c*.	7,477	13,275	65,246	884,939	*b*154,992	235,756	390,748	60.3
1903*c*.	2,825	14,856	73,264	556,835	107,279	146,056	253,335	53.7

(*a*) Not including 2,500 tons from Utah and small quantities aggregating 65 tons from Alabama, Missouri and North Carolina, of which the manganese content was not reported. (*b*) Not including 3,000 tons of manganiferous iron ore from Virginia, of which the metallic content was not reported. (*c*) Statistics of the U. S. Geological Survey.

Arkansas.—There has been little activity in the mining industry recently, although at one time the production of manganese was quite important. Some high-grade ore is obtained in the Batesville district, and there are deposits of ore in Polk county, but so far the latter have proved to contain too much phosphorus to be of value. The output of Arkansas since 1850 has reached a total of 50,000 tons.

Colorado.—The production of manganiferous iron ores in 1903 amounted to 14,856 long tons, the ore containing from 20 to 30 per cent Mn. In addition there was an output of 179,205 tons of manganiferous silver ores from the Leadville district, which were consumed by the silver-lead smelters.

Georgia.—The deposits of manganese ore occur in the northwestern section of the State around Cartersville, Rome, Cave Springs, Cedartown and Draketown. A part of the product is used for paint purposes, and the remainder is shipped to Birmingham, Alabama, for the manufacture of steel. The Georgia deposits have been described by Thomas Watson in THE MINERAL INDUSTRY, Vol. X and XI.

The price of manganese ore is determined by the Carnegie Steel Company according to the following schedule, which is based on ores containing not more than 8 per cent SiO_2 and 0.1 per cent P. Deductions are made of 15c. per ton for each 1 per cent of SiO_2 in excess of 8 per cent and of 1c. per unit of manganese for each 0.02 per cent in excess of 0.1 per cent. Ores delivered at the works of the company, at Pittsburg or Bessemer, Pa. Settlements are based on analyses of samples dried at 212° F.; the percentage of moisture in the samples as taken being deducted from the weight. Ores containing less than 40 per cent Mn, or more than 10 per cent SiO_2 or 0.15 per cent P, are subject to acceptance or refusal at buyer's option.

Tenor in Mn.	Price per Unit.		Tenor in Mn.	Price per Unit.	
Per Cent.	Fe.	Mn.	Per Cent.	Fe.	Mn.
Over 49.......	5c.	25c.	43 to 46........	5c.	23c.
46 to 49.......	5c.	24c.	40 to 43........	5c.	22c.

The imports of manganese ore in 1903, including manganese oxide, were 146,056 long tons, valued at $1,278,108, as compared with 235,576 long tons, valued at $1,931,282 in 1902.

Australia.—The output of manganese ore in Queensland and New South Wales is largely consumed locally in the gold chlorination plants. The production in Queensland during 1903 amounted to 1,320 long tons, and was used entirely by the Mount Morgan Gold Mining Company.

Brazil.—The exports of manganese ore in 1903 amounted to 161,926 metric tons, against 157,295 metric tons in the previous year. The principal mines are situated near Miguel Burnier, Queluz, Sao Goncalo and Piquiry, State of Minas Geraes, near Corumbá, State of Matto Grosso, and near Nazareth, State of Bahia. The deposits in the State of Minas Geraes are the most productive at present, the shipments in 1902 amounting to about 142,000 tons. There is a prospect of increased activity in the mines of Bahia, as the Brazilian government is contemplating the construction of a railway line into the manganese district. It is estimated that such a line would effect a saving of about $1.75 per ton in the carriage of ore from the mines to the port of Bahia.

Cuba.—The exports of manganese ore in 1903 were 18,795 long tons, against 39,628 long tons in the previous year.

Germany.—The principal mines are situated in the district of Bonn, and their product is a low-grade ore that should be classed as a manganiferous iron ore. The output of Germany in 1903 was 47,994 metric tons, valued at $130,000, against 49,812 metric tons, valued at $144,750 in the previous year.

WORLD'S PRODUCTION OF MANGANESE ORE. (*a*) (IN METRIC TONS.)

Year.	Austria-Hngary	Belgium.	Bosnia (*b*)	Brazil. (*d*)	Canada.	Chile. (*d*)	Colombia.	Cuba.	France	Germany	Greece.	India.	Italy.
1898..	14,219	16,440	5,320	26,417	45	20,851	11,176	*Nil.*	31,935	43,354	14,097	61,469	3,002
1899..	10,484	12,120	5,270	65,000	279	40,931	10,160	*Nil.*	39,897	61,329	17,600	88,520	4,356
1900..	14,550	10,820	7,939	108,244	27	25,715	8,748	21,973	28,992	59,204	8,050	132,767	6,014
1901..	12,077	8,510	6,346	100,414	399	18,480	695	25,586	22,304	56,691	14,166	135,307	2,181
1902..	12,883	14 440	5,760	157,295	76	12,990	*Nil.*	40,048	12,536	49,812	14,962	160,312	2,477

Year.	Japan	New Zealand.	Portugal.	Queensland.	Russia.	South Australia. (*d*)	Spain.	Sweden.	Turkey.	United Kingdom.	United States. (*e*)
1898..	11,517	220	907	68	329,546	5	102,228	2,358	....	235	190,787
1899..	11,340	137	2,049	747	659,301	102	104,974	2,622	49,468	422	145,548
1900..	15,228	166	1,971	77	802,234	*Nil.*	112,897	2,651	*d*38,100	1,384	221,714
1901..	16,298	208	904	221	(*c*)	134	60,325	2,271	(*c*)	1,673	649,016
1902..	(*c*)	*Nil.*	*Nil.*	4,674	(*c*)	18	46,069	2,850	(*c*)	1,299	989,519

(*a*) From official statistics. (*b*) Includes Herzegovina. (*c*) Statistics not available. (*d*) Export returns. (*e*) Includes output of manganiferous iron ore.

Greece.—The production of manganese ore in 1903 amounted to 9,340 metric tons, against 14,962 metric tons in 1902. There was also produced last year 152,520 tons of manganiferous iron ore, as compared with 170,040 tons in 1902.

India.—The production of manganese ore has increased rapidly in the last few years, placing India about on a par with Brazil. The output in 1903 amounted to 165,006 long tons. The principal deposits are situated in the Vizagapatam district of Madras (about 500 miles north of the city of Madras) and near Kamptee, in the Nagpur district of the Central Provinces.

Russia.—The depression that prevailed in the mining industry in 1901 and 1902 continued to be felt during last year. The industry appears to be passing through a critical stage due to the lack of organization among the mining and export interests and to the competition with other countries. In the Caucasus district, which supplies the larger part of the output, mining is carried on by small operators and it is said that the methods employed are crude and not adapted to the production of high-grade ore. A special commission appointed by the Russian government to examine into the causes of the depression reported in favor of granting a bounty on the exports of ore from the Caucasus and a reduction in railway rates, but its recommendations were refused, largely owing to the opposition of the mining interests in the Nicopol district.

The output of the Caucasus district in 1902 amounted to 408,571 metric tons, against 418,821 metric tons in 1901 and 661,154 tons in 1900. The mines in the Urals and Nicopol districts produced about 140,000 tons in 1900. The exports from Poti and Batoum in 1903 were 440,857 long tons, against 478,421 long tons in the previous year. The stocks at Chiaturi at the close of 1903 were estimated at 323,000 tons.

Spain.—The output of manganese ore in 1903, according to official reports, was 26,299 metric tons, valued at $92,124. The exports for the same year were 54,540 metric tons, valued at $459,940.

United Kingdom.—The output of manganiferous iron ore in 1903 was 818 long tons, as compared with 1,278 long tons in the previous year.

MONAZITE.

The production of monazite in 1903 showed a moderate increase over the output in the previous year, the total being 862,000 lb., valued at $64,630, against 802,000 lb., valued at $64,160, in 1902. The entire output was derived from Cherokee and Spartanburg counties, South Carolina, and from Rutherford, McDowell, Burke, Cleveland and Lincoln counties, North Carolina. Mining is usually conducted on a small scale, and consists in washing the alluvial sands that occur along the small streams in a wooden sluice, whereby a rough concentration is made. The crude material is then re-washed by the miners or, more frequently, is sold to one of the concentrating mills for final dressing. There are four concentrating plants in the district; the Carolina Monazite Company owns two mills, situated at Shelby, Cleveland county, North Carolina, and Gaffney, Cherokee county, South Carolina. The German Monazite Company has one mill, situated at Oakspring, Rutherford county, North Carolina; and the Incandescent Light & Chemical Company owns one mill near Carpenter's Knob, Cleveland county, North Carolina.

PRODUCION OF MONAZITE IN THE UNITED STATES.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Pounds.			Pounds.	
1893	130,000	$7,600	1899	330,000	$18,480
1894	750,000	45,000	1900	908,000	48,805
1895	1,900,000	114,000	1901	748,736	59,262
1896	17,500	875	1902	802,000	64,160
1897	40,000	2,000	1903	862,000	64,630
1898	150,000	7,500			

Brazil.—The exports of monazite from Brazil in 1902 amounted to 811 tons, valued at $81,115, which is considerably less than the shipments in 1901. Most of the Brazilian monazite is obtained from the province of Bahia, where it occurs in beach sands along the ocean. The village of Prado, not far from the island of Alcobaca, is the center of the mining industry. The mineral occurs also in the provinces of Minas Geraes, Goyaz, Cuyaba, Sao Paulo and Rio de Janeiro. New discoveries have been reported at Sapucaia, Rio de Janeiro, and along the Parahyba river. The Brazilian mineral is said to be finer-grained than the American, and it is also of more uniform grade, containing on the average 4.5 to 5.2 per cent thoria.

Norway.—Monazite is found in pegmatite dikes in southern Norway, and a small quantity is obtained as a by-product from feldspar mining. There was no output reported in 1901.

NICKEL AND COBALT.

There were no new developments of importance in the nickel industry during 1903. The consumption of nickel in the United States is mostly supplied at present from foreign material imported in the form of matte and refined in this country. The refining industry is controlled by the International Nickel Company, which also operates large mines in Canada and New Caledonia.

The following tables cover the statistics of nickel and cobalt in the United States during the last five years. No figures are obtainable as to the output of nickel from imported ores in 1903, but from the increase in the imports of ore and matte it is fair to assume that the production was larger than in 1902.

UNITED STATES PRODUCTION OF NICKEL AND COBALT.

	Nickel.				Cobalt Oxide.	
	From Domestic Ore.		From Foreign Ore.			
	Pounds.	Value.	Pounds. (a)	Value.	Pounds.	Value.
1899	22,500	$8,156	8,048,343	$2,917,525	10,200	$15,810
1900	3,715	4,534	7,713,120	3,597,713	12,270	22,035
1901	6,700	3,551	8,664,614	4,037,700	13,360	24,048
1902	5,748	2,587	10,391,478	4,520,293	20,870	45,450
1903	114,200	45,900	(b)	....	120,000	228,000

(a) Includes nickel in oxide and other forms, as well as metallic nickel. (b) Statistics not reported.

UNITED STATES IMPORTS AND EXPORTS OF NICKEL AND COBALT.

Year.	Nickel.				Cobalt.	
	Imports. (a)		Exports. (b)		Imports.	
	Long Tons.	Value.	Pounds.	Value.	Pounds.	Value.
1899	19,687	$1,101,939	5,004,377	$1,151,923	46,791	$68,847
1900	25,670	1,183,884	5,869,906	1,382,727	54,073	88,651
1901	52,111	1,637,166	5,869,655	1,521,291	71,969	134,208
1902	14,817	1,156,372	3,228,607	925,579	79,984	151,115
1903	15,936	1,285,935	2,414,499	703,550	73,350	145,264

(a) Ore and matte. (b) Comprises domestic nickel, nickel oxide and matte.

The discovery of cobalt and nickel near Marion, Ky., was reported during the year. The ore is associated with the deposits of fluorspar in that region and is said to contain as high as 5 per cent nickel oxide and 11 per cent cobalt oxide.

At Mine La Motte, Mo., the Mine La Motte Lead & Smelting Company has undertaken the construction of a smelter and refiner for treating the nickel and cobalt ores obtained in connection with lead mining. Heretofore a small amount of these metals has been produced by re-smelting the richer portion of the lead slags. In the new works the ores which contain nickel, cobalt and copper are smelted direct to crude matte. The matte is roasted in a McDougall furnace, charged into a small furnace, and the second matte again roasted. The product is then sent to the refinery, where both wet and dry processes will be used. The refinery is equipped with 165 solution tanks, two small furnaces, one Griffin and two buhr mills.

The second annual report of the International Nickel Company, a consolidation of mines and smelters in the United States, Canada, Great Britain and New Caledonia, including the Canadian Copper Company, Orford Copper Company, Anglo-American Iron Company, Vermilion Mining Company, American Nickel Works, Nickel Corporation, Limited, and the Société Minière Caledonienne was submitted on March 31, 1904. According to its statement of capital account the total assets of the company on that date were $30,896,167, divided as follows: Property of constituent companies, $26,864,275; Ray Copper mine, $40,000; advances to New Caledonia companies, $348,363; inventories, $2,827,774; cash and accounts, $815,755; total assets, $30,896,167. Common stock, $8,912,626; preferred stock, $8,912,626; stocks of constituent companies, $55,643; first mortgage 5 per cent bonds, $10,221,836; loans, accounts, etc., $1,617,476; depreciation fund, $412,709; surplus account, $763,251; total, $30,896,167. The income account for the year shows the following receipts: Earnings from constituent companies, $936,471; other income, $29,754. Charges were: For general expenses, $112,185; interest, $512,938; total, $625,123. The net balance carried to surplus account amounted to $341,102. The report further states that the cost of turning out the finished product was reduced during the year, and that further improvements in this direction are expected. An important saving in the item of fuel is anticipated as soon as the re-constructed works of the Canadian Copper Company are placed in operation. Exports during the year were disappointing, but there was an increased demand for nickel in the domestic market, owing to the new applications which have been found for nickel.

Market.—The market for nickel remained firm throughout the year, under the control of the trust. The prices quoted per ton and larger lots at New York were 40@47c. per lb., according to size and terms of order. For smaller lots as high as 60c. per lb. were quoted. It is to be noted that the market prices do not reflect the actual terms obtaining in business transactions, as large sales are commonly made at much lower prices than those quoted.

Canada.—According to the report of the Dominion Geological Survey, the production of nickel in 1903 was 12,505,510 lb., valued at $5,002,204, as compared with 10,693,410 lb., valued at $5,025,903 in 1901. The detailed statistics of Ontario, compiled by Thomas W. Gibson, Esq., Director of the Ontario Bureau of Mines, are as follows:

Schedule.	1899.	1900.	1901.	1902.	1903.
Ore raised............Short tons.	203,118	216,695	326,945	269,538	152,940
Ore smelted..........Short tons.	171,230	211,969	270,380	233,388	220,937
Per cent. nickel...............	....	1.67	....	2.55	3.16
Per cent. copper...............	....	1.59	....	1.78	1.81
Ordinary matte.......Short tons.	19,109	23,336	29,588	24,691	30,416
Bessemerized matte...Short tons.	106	112	15,546	13,332	14,419
Nickel content.......Short tons.	2,872	3,540	4,441	5,945	6,998
Copper content.......Short tons.	2,834	3,364	4,197	4,066	4,005
Value of nickel (*a*)............	$526,104	$756,626	$1,859,970	$2,210,961	$2,499,068
Value of copper................	176,236	319,681	589,080	616,763	583,646
Wages paid.....................	443,879	728,946	1,045,889	835,050	746,147
Men employed...................	839	1,144	2,284	1,445	1,277

NOTE.—The quantities reported in 1901, 1902 and 1903 under "bessemerized matte" include both bessemerized matte and high-grade matte, the former being the product of the Mond Nickel Company's works and the latter of the Ontario Smelting Works, which retreat the low-grade matte produced by the Canadian Copper Company. (*a*) Value based on nickel in matte and not on refined nickel.

An interesting discovery of nickel-cobalt arsenides in the northern part of the province of Ontario has been described by W. G. Miller.[1] The deposits are situated five miles south of the village of Haileybury, near Lake Temiscaming. Four veins have so far been found, all of which carry cobalt and probably nickel. Three of the veins are rich in silver. They cut through Huronian slate and conglomerate. One of the veins, which has a maximum width of six feet, carries niccolite and smaltite, together with native silver. A second ore-body contains a mixture of smaltite and probably arsenides of cobalt. Analysis of ore from this vein gave the following percentages: Cobalt, 16.8 per cent; nickel, 7 per cent; iron, 6.3 per cent; arsenic, 69 per cent. Three openings have been made on the vein over a length of 300 ft., the massive ore having a width of 14 inches. A third vein is about 8 inches wide on the average and contains cobalt bloom on the surface, though the unaltered ore probably consists of smaltite and niccolite.

The Sudbury Mines.

BY A. MCCHARLES.

Contrary to expectations, there was not as much work done in the Sudbury nickel mines during the season of 1903 as in each of the previous three or four years, but for three unusual reasons. A local scarcity of labor compelled the International Nickel Company to shut down all its mines for the summer months, and use most of the men in the construction of the new smelting plant. The result has proved very satisfactory in every way, as the company had sufficient ore mined ahead and on the roast-heaps to keep the old furnaces and the concentrating plant going the whole time. In fact, the

1 The Engineering and Mining Journal, December 10, 1903.

production of matte for October and November was the largest monthly output in the history of the company from the start.

Ground was broken for the new plant on April 20 on a very rough and rocky hillside behind the Copper Cliff mine, and a great deal of blasting and excavating had to be done for the foundation walls. But within one year from the commencement of the work the plant will be completed and ready to blow in; with two large furnaces, having a daily capacity of 500 tons each. There will be no change in the method of treating the ore, except that the ordinary matte from the smelting furnaces will be bessemerized into matte carrying 80 per cent in combined nickel and copper, precisely as at the works of the Mond Nickel Company, down the line. Large storage bins are also being built in connection with the new plant, so as to have a reserve stock of ore of about 20,000 tons at hand, to prevent any delays from changes of weather, railway accidents or other mishaps. These smelting works will be the first in the district to be almost entirely operated by electrical power, generated in a central steam plant. The buildings are all of brick and steel, and the equipment throughout will be of the most convenient and improved character that could be made. For the more economic handling of the ore and other materials used at the furnaces, the company has built a number of 50-ton drop-bottom dump-cars, and purchased two new 80-ton locomotives, one of which is largely made of nickel steel. Mr. A. P. Turner is general manager of all the company's works and mines in the Sudbury district, and the head office is at Copper Cliff.

A detailed description of the plant will be found in THE ENGINEERING AND MINING JOURNAL, December 31, 1903. The blast-furnace building contains two Holthoff copper blast-furnaces, three stands for Holthoff converters, a 40-ton electric crane, matte settlers, etc., while room is provided for expansion. The blast-furnaces are 50 by 204 in. at the tuyeres; 14 ft. 9 in. from tuyeres to the feed floor, and have on each side four lower jackets, each 51 in. wide and 8 ft. 6 in. high, and two upper jackets 8 ft. 6 in. wide and 6 ft. high. Both ends of the furnace are made alike, so that either end can be used for removing matte and slag. The converters are 84 in. by 126 in. In operation the ore, coke and flux, with the silica and clay for lining converters, are delivered into trestle pockets by standard-gauge cars and drawn from the bottom of the pockets into cars, which are hauled to the blast-furnace or storage bins by electric locomotives. The slag and matte run from the blast-furnace into 16-in. settlers, the slag overflowing into cinder cars, which are hauled to the dump. The matte is tapped into 10-ton cast steel ladies and taken to the converter by an electric crane. The flue-dust is drawn from the dust-chamber into a standard-gauge bottom-dumped gondola to the storage pocket, whence it goes to a briquetting machine, and is then pressed into briquettes and added to the charge.

Work was suspended in the spring by the Mond Nickel Company on the

Victoria mine, which is a very large and valuable ore-body, and fully opened up to the 700-ft. level and ready to stope out. The only ore raised by this company during the rest of the season was about 100 tons a day from the North Star mine. But that mine also, as well as the smelting works of this company, was closed down at the end of November last, for the simple reason that more matte had been made than the Mond nickel refinery at Clydach, Wales, could treat. But the capacity of the refinery is being doubled now, and operations at the company's mines and works will likely be resumed on the old scale in the spring.

The Lake Superior Power Company, that was to have revolutionized the nickel industry of northern Ontario by supplying the whole world with ferronickel and utilizing the sulphur and other by-products in the ore, has not succeeded in accomplishing either, and the nickel mines and smelting plant of this company were shut down some months ago. But it is hoped that the company, which really owns several good nickel properties, will get over what is locally known as the "financial cramps" in some way, and begin to work again under more practical and economic management than in the past.

A syndicate of American capitalists, with headquarters in Milwaukee, Wis., bonded the Mackenzie mine, in the township of Levack, last summer, and did considerable stripping and other surface work before the winter set in, which was earlier than usual last year. Since then a diamond drill has been employed on the property in testing the extent and character of the ore-deposit to some depth.

Hidden mines are hard to find, and especially in the Sudbury district, with its overburden of clay, sand and muck on the low, swampy lands. But Thomas A. Edison has had a party, composed mainly of young college students, trying to locate and find such mines, with the dip needle, in different parts of the nickel belt for the past three seasons; and he also last year began to exploit two of the claims with a diamond drill, but with what result, if any, has not been made known yet. To show how thoroughly the old prospectors, few in number, and with only a very poor knowledge of the surface indications of a nickel mine, did their work, it is enough to state that not a single discovery of any value has been made on the whole nickel belt for many years past.

A nickel refinery in the Sudbury district, in the near future, will probably be one of the minor results of Chamberlain's imperial policy. Canada wants it.

WORLD'S PRODUCTION OF NICKEL. (METRIC TONS.)

Year.	Canada.	France.	Prussia.	United Kingdom.	United States.
1899	2,605	1,740	1,105	1,350	3,671
1900	3,212	1,750	1,376	1,450	3,503
1901	4,168	1,800	1,660	1,750	3,646
1902	4,850	1,100	1,200	1,310	4,714

NOTE.—The production figures for France, Prussia and United Kingdom represent nickel made from imported ores. The figures for the United States represent nickel made from both domestic and imported ores; the output from domestic ores is, however, small, having been 10 tons in 1899, 4 tons in 1900, 3 tons in 1901, and 2 tons in 1902.

New Caledonia.—The year's developments in the nickel and cobalt industries are reviewed by F. Danvers Power on a subsequent page of this volume.

The exports of nickel ore in 1903 amounted to 77,360 metric tons, as compared with 129,653 tons in 1902; the exports of cobalt ore were 8,292 tons, against 7,512 tons in the preceding year. The decline in exports of nickel ore was largely due to the heavy accumulation of stocks in America during 1901 and 1902 in anticipation of a change in the Canadian tariff laws.

The International Nickel Company and Société le Nickel are the chief operators of mines in New Caledonia. A new company, known as the Consolidated Nickel Mines, has been formed recently to take over the properties of the Société d'Exploitation at Koriambo, Katepai and other localities on the island. The company intends to ship its ore to the works of the Smelting Company of Australia for treatment.

Some details as to the costs of making nickel from New Caledonia ores have been set forth in an article by M. Glasser.[1] According to this authority, the cost of mining averages at least 25 fr. per dry ton of ore f. o. b., in addition to which the general expenses amount to 10 or 15 fr. This makes a total cost of 35 to 40 fr. as a minimum, compared with a value, on a basis of 7 per cent nickel, of 42 to 49 fr. per ton. The ores sold in Europe have to pay an ocean freight of 30 to 40 fr. per ton, equal to 45 to 50 fr. dry weight, or 0.70 to 0.75 fr. per kg. of contained metal. The treatment in Europe costs about 1 fr. per kg. of nickel.

New South Wales.—The cobalt deposits near Port Macquarie have been productive for many years, although the output has never reached large proportions. In 1903 the quantity of ore exported for treatment was 153 long tons, valued at $7,850, which compares with 34 tons, valued at $1,520 in 1902.

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1 See The Engineering and Mining Journal, May 5, 1904.

PETROLEUM.

The production of petroleum in the United States in 1903 reached the enormous total of 100,496,400 bbl., by far the largest ever recorded in the history of the industry. As compared with the previous year the figures show an increase of 11,311,903 bbl., or approximately 13 per cent, while the gain since 1901 has been no less than 44 per cent. The greater part of the increase last year was contributed by California which reported a production of 24,340,839 bbl. against 14,356,910 bbl. in 1902, placing it first among the petroleum-producing States. The Lima field of Indiana enlarged its output by 1,641,561 bbl., almost equal to the increase reported in 1902. This State has more than doubled its production within the last four years. Kansas reported a yield of 1,018,199 bbl., as compared with 322,023 bbl. in 1902, Louisiana 917,771 bbl., against 548,671 bbl. in 1902, and Kentucky 554,286 bbl., against 185,331 bbl. in 1902. There were smaller increases in Colorado, Indian Territory, Oklahoma and Wyoming. In Texas the production was but little less than the total reported in the previous year, the totals being 17,955,572 bbl. in 1903 against 18,083,658 bbl. in 1902. The great expansion in the Sour Lake field and the discovery of the new field at Batson's Prairie sufficed to make up for the rapid decline at Beaumont.

PRODUCTION OF CRUDE PETROLEUM IN THE UNITED STATES. (BARRELS OF 42 GAL.)

Year.	Appalachian Field.	California.	Colorado.	Indiana, (Lima Field.)	Kansas.	Ohio. (Lima Field.)	Texas.	Wyoming.	Other States.	Total.
1899.	32,870,689	2,677,875	600,000	3,818,713	69,556	16,565,092	601,308	6,071	e 25,000	57,234,304
1900.	35,540,965	4,250,000	525,000	4,329,950	65,000	e16,407,704	800,000	7,200	e 30,000	62,538,544
1901.	33,618,180	8,786,330	460,520	5,757,086	179,150	16,176,293	4,393,660	5,400	12,623	69,389,194
1902.	32,018,787	14,356,910	e 396,901	7,535,561	322,023	15,877,730	18,083,658	6,253	586,674	89,184,497
1903.	29,897,815	24,340,839	483,925	9,177,122	1,018,199	e16,000,000	17,955,572	8,960	1,613,968	100,496,400

(*e*) Estimated.

A striking feature of the year's record was the increased importance of the low-grade heavy oils, as compared with the higher grades, in the total production. This change in the relative conditions of the producing industry has been in progress for some time, but has been greatly accentuated by recent results. In 1900 the Appalachian and Lima fields contributed 92 per cent of the total output of the country, in 1901 they contributed 80 per cent, in 1902 62 per cent, and in 1903 but 55 per cent of the total.

The stocks of oil on hand at the end of the year in the Appalachian and

Lima districts are given in the following table, in which the quantities are expressed in barrels of 42 gal.:

Appalachian.				Lima.			
1900.	1901.	1902.	1903.	1900.	1901.	1902.	1903.
13,147,717	9,635,492	5,699,127	4,823,199	14,988,928	17,760,306	17,463,518	15,138,637

The average prices of petroleum in the Appalachian and Lima fields are shown below:

MONTHLY AND YEARLY AVERAGE PRICE OF PIPE-LINE CERTIFICATES PER BARREL OF CRUDE PETROLEUM AT THE WELLS IN THE APPALACHIAN FIELD.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Average.
1899.....	$1.17	$1.15	$1.13	$1.13	$1.13	$1.13¼	$1.22½	$1.27½	$1.44½	$1.50⅞	$1.57⅜	$1.65⅛	$1.29⅜
1900.....	1.66⅔	1.68	1.68	1.55	1.39⅜	1.25½	1.25⅝	1.25½	1.23	1.10⅜	1.06¾	1.08¾	1.35¼
1901.....	1.69½	1.25	1.29	1.20½	1.07⅜	1.05	1.13⅜	1.25	1.25⅜	1.30	1.30	1.21	1.21
1902.....	1.15	1.15	1.15	1.17½	1.20	1.20	1.22	1.22	1.22	1.28	1.38	1.49	1.24
1903.....	1.52	1.50	1.50	1.51½	1.51½	1.50	1.53	1.56	1.56	1.69½	1.79½	1.88½	1.59

AVERAGE MONTHLY PRICES OF CRUDE OIL IN THE LIMA FIELDS.

Month.	1900.			1901.			1902.			1903.		
	North Lima.	South Lima.	Indiana.	North Lima.	South Lima.	Indiana.	North Lima.	South Lima.	Indiana.	North Lima.	South Lima.	Indiana.
January. .	$1.19¾	$1.14¾	$1.14¾	$0.87¼	$0.82¼	$0.82¼	$0.85	$0.80	$0.80	$1.14	$1.09	$1.09
February.	1.24½	1.19½	1.19½	0.91	0.86	0.86	0.85	0.80	0.80	1.11	1.06	1.06
March . . .	1.26	1.21	1.21	0.93½	0.88½	0.88½	0.85	0.80	0.80	1.11	1.06	1.06
April	1.19	1.14	1.14	0.88¼	0.83¼	0.83¼	0.86½	0.81½	0.81½	1.14	1.09	1.09
May	1.08	1.03	1.03	0.80½	0.75½	0.75½	0.88	0.83	0.83	1.15½	1.10½	1.10½
June.	0.95½	0.90½	0.90½	0.79	0.74	0.74	0.88	0.83	0.83	1.14	1.09	1.09
July	0.95	0.90	0.90	0.84	0.79	0.79	0.89	0.84	0.84	1.15½	1.10½	1.10½
August. . .	0.93½	0.88½	0.88½	0.91	0.86	0.86	0.89	0.84	0.84	1.18	1.13	1.13
September	0.91⅙	0.86⅙	0.86⅙	0.91¼	0.86¼	0.86¼	0.89	0.84	0.84	1.18½	1.13½	1.13½
October . .	0.82⅛	0.77⅛	0.77⅛	0.94	0.89	0.89	0.93	0.88	0.88	1.26	1.21	1.21
November	0.80	0.75	0.75	0.94	0.89	0.89	1.00⅖	0.95⅖	0.95⅖	1.33¼	1.28¼	1.28¼
December	0.87	0.82	0.82	0.88⅝	0.83⅝	0.83⅝	1.10	1.05	1.05	1.37¼	1.32¼	1.32¼
Average	$1.01¾	$0.96¾	$0.96¾	$0.88½	$0.83½	$0.83½	$0.90⅗	$0.85⅗	$0.85⅗	$1.19	$1.14	$1.14

The exports of mineral oils from the United States during the past five years are given in the subjoined table. The statistics show that there was a decided falling off in the quantity of the exports in 1903, although in most cases the valuation was larger than in the previous year.

EXPORTS OF MINERAL OILS FROM THE UNITED STATES. (IN GALLONS.) (1=1,000 IN QUANTITIES AND VALUES.) (*a*)

Year.	Crude Petroleum.		Naphthas.		Illuminating.		Lubricating and Paraffine		Residuum.		Totals.	
1899......	118,690	$5,958	18,210	$1,597	733,393	$49,173	71,105	$8,656	21,609	$658	962,007	$66,042
1900......	133,161	7,341	18,570	1,681	739,163	54,693	71,211	9,933	19,750	845	986,855	74,493
1901......	127,008	6,038	21,685	1,742	827,479	53,491	75,306	10,260	27,596	1,255	1,079,059	72,786
1902......	145,234	6,331	19,683	1,393	778,797	49,079	82,200	10,872	38,316	922	1,064,230	68,597
1903......	126,512	6,782	12,973	1,519	691,837	51,356	95,622	12,690	9,755	282	810,287	72,629

(*a*) In addition to the above, the following quantities of paraffine and paraffine wax were exported: 1899, 181,861 lb. ($7,650); 1900, 157,108 lb. ($8,186); 1901, 151,695 lb. ($7,960); 1902, 175,200 lb. ($8,398); 1903, 204,119 lb. ($9,596).

The Use of Petroleum in Laying Dust.—According to a pamphlet issued by a French society, crude petroleum, mazoot, coal tar and heavy tar oil have been used with more or less success for laying dust on roads. To successfully apply oil for dust laying it is essential that the road should be perfectly dry and have a hard even surface. As regards the influence of road metal on the results, trials made in France show that porphyry rock is preferable to sandstone, owing to the more regular wear of the particles. The methods of application vary in different cases. In California it has been found better to spray the oil over the layer of dust instead of on the bare macadam. The oil is warmed to 70° or 80° C. and is sometimes injected under pressure. In a series of experiments carried out at Los Angeles, Cal., three dressings of oil were given the first year and one in each succeeding year. For the first dressing about one quart of oil per square yard was used, but the quantity was reduced to one and one-half pints in the subsequent dressings. The total cost for the work was about 2c. per square yard per annum. Experiments made in France, on the other hand, gave the best results on surfaces cleaned from dust, especially when using coal tar. Several different types of spraying machines have been used in France. For large surfaces the sprayer consists of a cylinder, holding about 45 gallons, mounted on a pair of wheels. The tar or petroleum is distributed by a perforated pipe in the rear of the machine over a breadth of about 5 ft. After spraying the tar is levelled with hand brooms. The time required for the tar to set is from two to five days. With mazoot the consumption is about one and one-half pints per square yard. A new compound known as "westrumite," which is said to be a mixture of mineral and vegetable tar oils rendered soluble in water by ammoniacal saponification, has been tried in France, and the results are said to have been excellent.

Alaska.—Petroleum has been found in Alaska in four fields. The first and most promising strike was made in the Kayak field, on Controller bay, at the mouth of the Copper river. The well opened in 1902 was capped and drilled deeper, being reopened in July, 1903. The flow was encouraging, and four additional wells were sunk during the summer of 1903. The other fields are on the western shore of Cook's inlet; at Cape Yakatag, near Mount St. Elias; and on the Alaska peninsula, in the vicinity of Cold bay. Most of the work in Alaska up to date has consisted of prospecting, although three gushers had been reported in the Kayak field up to February, 1904. Experts who have examined the territory regard it as most promising.

Appalachian Field.—The steady increase in the prices of crude oil during 1903 served to stimulate prospecting and drilling operations, but the results were hardly satisfactory. The production showed a further decline, falling to the lowest point in several years, and necessitating a heavy drain upon the stocks. It would appear that there is little hope for extending the productive territory in this field, and the output will probably continue to decline.

California.—The petroleum industry made great progress during 1903, and the output exceeded that of the previous year by nearly 10,000,000 bbl. According to statistics compiled by the California State Mineralogist the product amounted to 24,340,839 bbl., valued at $7,313,271, as compared with 14,356,910 bbl., valued at $4,692,189 in 1902. A review of the year's developments in the industry will be found on another page in this chapter.

Indiana.—The petroleum industry was in a very satisfactory condition during 1903, and the output amounted to 9,177,122 bbl., as compared with 7,535,561 bbl. in the previous year. There was a large amount of new work done, the number of wells drilled being 3,686 or 754 more than in 1902. On December 15th, 1903, there were 11,980 productive wells in the Lima field, and the output for that month was 796,291 bbl., or an average of 2.14 bbl. per well per day. Several wells were drilled in the vicinity of Birdseye, Dubois county, for the purpose of testing the Corniferous limestone. Some oil was found, but the field has not yet become an active producer.

Kansas.—There are eight districts in the Independence field of Kansas, and one over the line in Indian Territory. The production of Kansas wells during 1903 was 1,018,199 bbl., valued at $1,120,019. The Chanute district is the most active, and 104 companies were operating there early in 1904. Of the 2,180 wells in the entire field, Chanute has 1,189. The Neodesha, Peru and Muskogee fields are producing fairly. The Standard Oil Company has made surveys for a pipe line to Chanute, extending to Tulsa, in the Indian Territory.

Kentucky.—The output of the Kentucky-Tennessee field in 1903 was 554,286 bbl., as compared with 185,331 bbl. in the previous year. The Wayne county excitement reached its height about the middle of 1903, and there were in June, 1904, 170 wells there, producing over 550 bbl. a day. Since the large strike of July, 1902, in the Cumberland district, about 100 wells have been sunk there, half of which are good producers.

Louisiana.—The petroleum industry in this State made good progress during 1903. The output amounted to 917,771 bbl., against 548,617 bbl. in 1902. At the beginning of the present year there were 75 pumping wells and four flowing wells in the Jennings field, and the production was about 6,000 bbl. daily.

Missouri.—The oil district near Belton, Cass county, opened in 1902, now includes seven producing wells.

Texas.—The production of petroleum in 1903 amounted to 17,955,572 bbl., as compared with 18,083,658 bbl. in the previous year. The Beaumont field reached the highest development in 1902 when it produced about 16,000,000 bbl. In the early part of that year the pressure in the flowing wells began to decrease, and in a few months it became necessary to install pumping apparatus. The output in 1903 was less than half of the preceding year. The falling off from this source, however, was about counterbalanced by the great increase in the yield of the Sour Lake and Saratoga fields. Near the close of the year a new field was opened, known as Batson's Prairie. A well was put down in November which began flowing at 630 ft. It was drilled deeper, and at 1,150 ft. encountered a reservoir under great pressure. A second flowing well was opened in December and gave the incentive for an influx of prospectors from the older fields.

The shipments of oil from Port Arthur in 1903 amounted to 7,573,000 bbl. The J. M. Guffey Petroleum Company and the Gulf Refining Company were the largest shippers. The former company has begun the construction of a 6-in. pipe-line to the Batson Prairie field, and other lines are contemplated. Plans have been considered for the erection of a large refinery at Sour Lake.

Wyoming.—The most successful oil field in this State is at Salt Creek, 50 miles north of Casper, in Natrona county. The Belgo-American Drilling Trust has sunk 13 wells here, and has a good pumping plant. The oil is heavy and has very little illuminating quality, but it is an excellent lubricating oil, possessing great viscosity and freedom from gummy products. The local refinery at Casper secures from 75 to 90 per cent of lubricating stock from the oil, and manufactures 15 oils of different grades. The annual yield of the Salt Creek field is 5,000 to 6,000 bbl. It is expected that several of the minor fields will produce in the near future.

PRODUCTION OF CRUDE PETROLEUM IN FOREIGN COUNTRIES. (*a*) (IN METRIC TONS.)

Year.	Austria.	Hungary.	Canada.	Germany.	India.	Italy.	Japan.	Roumania.	Russia.
1898..	234,142	2,471	98,044	25,789	71,627	2,015	(*b*) 59,980	180,000	7,841,671
1899..	309,590	2,125	113,718	27,027	106,000	2,242	(*b*) 100,882	250,000	8,470,925
1900..	347,213	2,199	91,139	50,375	140,034	1,683	(*b*) 106,443	250,000	10,524,919
1901..	404,662	3,296	79,537	214,095	185,877	2,246	(*b*) 100,127	270,000	(*c*) 10,879,736
1902..	520,847	4,347	66,642	49,725	206,689	2,633	....	310,000	(*c*) 10,327,044

(*a*) From the official reports of the respective countries. This table is not complete since it does not include the production of Sumatra, Borneo, Java, South Africa, Peru and some other countries. (*b*) Crude oil only. In 1901 Japan also produced 11,214 tons of refined. (*c*) Output of Baku fields.

Algeria.—The existence of petroleum deposits in Algeria has been known for many years. At Admittons a large field has been investigated recently, and oil obtained at depths between 350 and 600 ft. Analyses show specific gravities ranging from 0.80 to 0.83, and flashing points from 95° C. to 135° C.

Austria-Hungary.—The Galician wells at Boryslaw are increasing in importance, the product in 1903 being 735,570 metric tons. The exports during the year included 51,983 tons of illuminating oil, 19,869 tons of lubricating oil and 13,963 tons of benzine. The local government has recently ordered storage tanks built for public use of a capacity of 100,000 tons. At present most of the Galician oil is produced from shallow wells, but lower strata have been found between 650 and 1,000 ft., and productive borings have been made as low as 1,960 and 2,850 feet.

Canada.—The production of petroleum in 1903 showed a continuance of the steady decrease which has marked the industry for ten years past. The yield amounted to 461,336 bbl., as compared with 521,485 bbl. in 1902. The district of Lambton county remains the chief source of supply, and there has been no expansion in the productive territory. The Canadian refiners favor a reduction of the import duty on crude petroleum, which is now five cents per gallon. It is believed that if the duty were lowered to two cents the importation of crude, rather than refined, petroleum would be encouraged to the benefit of the Canadian refiners.

Dutch East Indies.—Six active companies are operating in the Borneo and Sumatra fields, producing and refining petroleum. One of the largest refineries is that of the Moesi-Ilir Petroleum Company, which controls a group of spouters near the town of Palembang. The Dordtsche Petroleum Company owns numerous concessions in Java and Madura, the total area being over 800,000 acres. This company controls three refineries and 125 miles of pipe-line.

Formosa.—Petroleum is found in the central portion of the island, from Bioritzu to Baushorio, and also in the northern part. Since 1897 five concessions have been obtained by Japanese concerns, and test wells have been put down in a number of localities. The development of the industry is retarded by lack of capital.

Germany.—The fields of Alsace produced about 25,000 tons of crude oil in 1903. The Hanoverian field, sometimes called the Wietze field, has attracted more or less attention for half a century. Oil was struck in 1876, but no very satisfactory results were secured until 1900, when a number of large spouters were opened in deep strata. The production in 1900 was 27,042 metric tons, falling off to 23,396 tons in 1901, and increasing to 28,797 in 1902. The production for 1903 was about 40,000 tons. There are about 150 producing wells, and boring is quite active, while refineries are being erected at Linden and elsewhere. The oil is black, thick, and resembles the heavy Baku lubricating residuals. It usually contains about one-half of one per cent of benzine, 10 per cent of petroleum, 60 per cent of lubricating oil and 20 per cent of tar. A light oil, producing a large percentage of illuminant, has been discovered in a deep stratum. The German railways use the native heavy oil for lubrication almost exclusively. Nearly 90 per cent of the petroleum consumed in Germany comes from the United States, but the Russian and Roumanian oils are finding a larger market.

India.—The Burmah fields now include about 150 producing wells. Large refineries have been erected at Rangoon. The tankage facilities at Rangoon and Calcutta are being increased, and tanks are being erected at Chittagong, Madras, Bombay, Karachi, Marmago and other ports. Considerable burning oil is being shipped to Calcutta, and paraffine candles are made and shipped to numerous eastern markets. A 400-mile pipe-line has been begun, and is to be completed early in 1905. Nearly all of the oil territory of India belongs to the government, and drillers pay a royalty of 60c. per 40 gallons. The production in 1902 was 56,607,688 gal., and the imports for the same year about 81,000,000 gallons.

Italy.—The output of petroleum from Italian wells during recent years has averaged about 2,500 tons per annum, the highest figure being in 1895, when it reached 3,594 tons. Petroleum is found in the northern belt of the Apennines and in the Abruzzi. About 300 wells have been sunk in all, and they show an average life of from six to seven years. The oil is reddish-yellow in color and rather light.

Japan.—No less than 98 companies are engaged in the petroleum industry. The output in 1900 was 1,639,104 barrels, and this increased in 1903 to about 2,170,000 barrels. The most valuable wells are in the province of Echigo, in the extreme northern island of the empire. The Takarada company is the largest of the Japanese companies and owns 160 wells and five refineries. An American company, the International Oil Company, entered the field in 1900 and combined many of the smaller companies, besides establishing large refineries. The present production only about half supplies the home demand.

Persia.—An English company in 1901 secured the right to exploit petroleum deposits in southwest Persia. Up to the beginning of 1904 they had expended about $40,000 without profitable results. It is reported that a large flowing well has been opened near Gatil-Sherin, on the Turko-Persian frontier.

Roumania.—The petroleum product of the Roumanian fields exhibits a steady increase, the official statistics showing an output of 384,302 metric tons of crude oil in 1903, as against 310,000 tons in 1902. At the close of 1903 there were 145 producing wells, a gain of 19 for the year. In the Prahova field there was a gain of 11 producing wells. Nearly half the product is controlled by one concern, the Steaua Romana, but the Telega, International and Bustenari companies are also important producers. The Roumanian government is assisting the development of the industry, having started geological surveys, and built storage tanks at Constantza, the port of shipment. Tank steamers and tank wagons have been provided by the government, which is also making surveys for a pipe-line from Prahova to Constantza. A refinery has been started at Cernavoda, and other refineries have increased their capacities, notably at Campina, Baicoi, Plopeni and Tirgoviste. The Prahova district refineries treated 259,398 tons in 1903, and the total for the field was 314,748 tons, as against 215,575 in 1902. The consumption of petroleum products in the Roumanian market shows a slight increase, from 113,937 tons in 1902 to 132,180 in 1903. The prices of all the products except benzine increased during the year.

Russia.—The production at Baku in 1903 showed a falling off as compared with 1902, and a still greater decline as compared with 1901. The output in 1903 was 71,626,611 bbl., against 76,383,463 bbl. in 1902, and 80,553,152 bbl. in 1901. The causes assigned for the reduction are a strike at Baku in July, lasting from 10 to 20 days, and fire in the Bebe-Aibat district in September which destroyed 62 rigs. No new oil territory was developed in 1903, the new wells being all in old territory. At the opening of 1903 only 315 wells were being drilled, as against 416 a year before. The number of wells completed in 1903 was 189, against 236 in 1902; the average production per well was 317 bbl., against 292 bbl. in the latter year.

Notwithstanding the reduced number of wells drilled in 1903, there were 23 more producing wells at the close of that year than at the close of 1902. As from one to two years are required from the commencement of drilling until a well becomes a producer, the outlook for increased production is poor. The production by flowing wells, as compared with the output by pumping, appears below:

	1902.		1903.	
	Spouters.	Pumping.	Spouters.	Pumping.
	Tons.	Tons.	Tons.	Tons.
Balakhany	......	1,637,165	......	1,452,089
Saboontchi	163,650	4,145,366	49,370	3,794,604
Romany	621,720	1,535,410	215,121	1,964,670
Bebe-Aibat	743,310	1,312,059	612,082	2,576,402

The shipments of petroleum from Black Sea ports (Batoum and Novorossisk), in barrels of 42 gallons, were as follows:

	Crude and Residuum.	Lubricating oil.*	Solar and Distillate.†	Refined.
1902	396,278	1,100,855	1,080,329	8,443,872
1903	457,264	1,332,131	1939,179	9,466,631

* Batoum only. † Includes some benzine from Novorossisk.

The stocks of crude oil at Baku at the beginning of 1904 compared with the previous year were:

	January 1, 1903.	January 1, 1904.
At the wells	1,218,067 barrels.	987,102 barrels.
At the refineries	3,378,335 barrels.	4,642,717 barrels.

The oil lost because of the strike is estimated at 2,100,000 barrels, and the loss by fire at about the same amount.

There was a general depression in prices during 1903, with a slight recovery in the last quarter. The cost of production is estimated by the United States consul at Batoum at from 4.1 to 4.6 per pood at the wells, or about 35 to 40c. per barrel.

The Bebe-Aibat district was leased by the government some years ago, during a period of high prices, and when the prices declined in 1901, the profits were so reduced that drilling almost ceased. The lessees petitioned for a reduction of royalties, based on a proportion of the oil. The government reduced the figure, and ordered a new auction, which took place July 15. After that date the drilling of wells was pushed with much increased energy. In September came the fire, involving five wells with a large loss in production. Since the fire the wells did not flow as much as hoped for, and there was renewed dissatisfaction among the lessees. The government therefore annulled the leases, and will charge royalty of 30 per cent until October 14, 1904, when another auction of leases is to be held.

The refining business was regarded as unsatisfactory during the first nine months of the year, after which time a demand arose for refined oil for export, and a great rise in prices resulted, the advance in refined in October being 150 per cent, while crude advanced 100 per cent.

According to the report of the U. S. Consular agent at Batoum the cost of refined oil is about 12.4 cents per pood, which yields a profit of 2.8 cents per pood for the refined oil exported. The report also shows that more illuminating and lubricating oils are being taken from the residuum, reducing the yield of the latter in the proportion of 54.15 per cent for 1903, against 61.83 for 1902.

There has been a slight advance in freight rates between Baku and Batoum, amounting to about two cents per gallon on refined oil. A short pipe-line, known as the Baku-Aibat pipe-line, has been put into operation from the refining district of Baku to Volchi-Vorota. This line is being extended, and it is announced that it will be completed from Baku to Batoum by July, 1905. When completed it will double the capacity of transportation of refined oil to Batoum.

Spain.—There has been considerable exploration in the vicinity of Huidobro, with favorable results. Several companies are operating in the field.

Turkestan.—The indications of petroleum in Turkestan are numerous. The opening of the trans-Caspian railway has stimulated exploration. The government made test borings in 1902 in the Narine valley, and prospecting has been done in several other district fields. The most promising of these is southwest of Magellan, where a well was sunk 860 ft., and yielded by bailing about 5,000 kg. per day.

The Petroleum Industry of California.

BY C. T. DEANE.

Notwithstanding the rapid increase in production, the consumption of petroleum in California has advanced with almost equal pace and is likely to continue its progress in the future. All the railroads in the State are using oil-fuel in their locomotives and machine shops; they are installing tankage as fast as possible. A number of manufacturing establishments are using oil, figuring a saving in cost of fuel. All street railroads, both electric and cable, throughout the State, use oil only. The electric light and gas companies use large quantities. Most of the gas consumed in the State is now enriched with oil. Of the lubricating oil used here, 75 per cent is made in local refineries; heretofore all was imported from the East. There are 40 refineries now in existence, an increase of seven in 1903; these refineries make kerosene, distillate, lubricants, asphaltum, coke, etc. Since the beginning of the year the Standard Oil Company's great pipe-line has been completed most successfully; it is transporting in the neighborhood of 10,000 bbl. per day, and all of this is being used at the large refinery. This pipe-line is 278 miles long, and the pipe is 8 in. in diameter; there are pumping stations at intervals of 28 miles; the oil has to be heated to about 120° F., as in its natural condition it has the consistency of black molasses. It is assumed that the company is refining the oil for kerosene; the refinery also turns out large quantities of coke. There is no doubt that asphalt-base California crude oil can be refined into illuminating oil at a profit, and in a short time the State will be producing all the illuminating oil needed on the Coast, and also exporting it to the Orient.

There are, in California, a large number of oil districts of varying importance, commencing at the extreme south of the State and running north, along the foothills, for 500 miles, or from south of Los Angeles to within a few miles of San Francisco, at Half Moon bay; there are strong indications and seepages still further north, in Colusa county, but as yet no commercial well has been developed in that locality. There is one oil region in the State, that of Kern river, which has great possibilities. It includes about 4,000 acres of proved land, with a depth of oil-sand averaging 400 ft. Many wells pump continuously from 100 to 250 bbl. per day. Some of the other districts are also good producers, notably Sunset, Coalinga, McKittrick, Fullerton and Santa Maria, about in the order named. A well in this State is not considered of commercial importance unless it pumps at least 50 bbl. a day, and a company must have several wells to make any money at present prices.

There are in California four buyers of oil—the Standard Oil Company, which owns no wells; the Associated Oil Company, owning probably half the wells in the Kern River district and two-thirds of the wells in McKittrick; the Southern Pacific Railroad, and the Union Oil Company. These last three own wells themselves, but also buy some oil from independent producers; however, the Standard sets the price, and as it has large contracts running for three years yet, it is very independent; if a combination of outside interests could be brought about, oil might quickly appreciate in value; but, as long as companies with ten or more wells can make money at present prices, they will sell their oil, and unless consumption increases faster than production, this state of affairs will continue. There are probably enough wells now drilled to produce 30,000,000 bbl. in 1904, and if all work on new wells should cease, oil would rapidly increase in value; but there is no hope of that, and the owners, by being in too great hurry to develop their property, will keep the price at about the present figures for some time to come.

The cost of developing an oil property in California depends very largely on the district in which it is situated; in the Kern River, Sunset, McKittrick or Coalinga districts, wells can be drilled 1,000 ft. deep for about $3,000 each, or 10 wells can be put on the pump, including all outlays, for $50,000; the cost of the land, of course, will vary in each district, or a favorite way now is to lease land on a royalty; this also varies according to location.

The increased production of petroleum is perhaps the greatest single factor in the prosperity of the Pacific Coast for the past few years. It not only kept a large amount of money here, that would otherwise have gone to foreign countries for coal, but it has enabled local manufacturers to compete with those of the Atlantic seaboard; this money has gone into real estate, to develop oil properties, and into new manufacturing plants.

It might be well here to give a comparison of the steam energy as between coal and oil. Sixteen tons of oil (or 104 bbl.) give the same horse-power as 25 tons of the best steam coal. The evaporation per pound of coal at 212° is 9.17 lb. The evaporation per pound of oil at 212° is 15.1 lb.; thus 1,362 lb. oil (or about 4 bbl.) seem equivalent to 2,040 lb. of coal, which gives a ratio of efficiency of oil to coal of 1.65 to 1.

A very important future use for fuel-oil is in marine boilers. There are at present nearly 200 vessels, large and small, using oil in and out of this port. Ferryboats, bay and river steamers use oil. There are at least 25 ocean steamers plying between Hawaiian Islands, and also the mail steamers between San Francisco and Tahiti, which carry sufficient fuel for the round trip. There is fitting up now, at the Risdon Iron Works, a large steamship which runs between San Francisco and New York by the straits of Magellan; she will carry sufficient oil for her entire trip, without stopping en route. The cost of fuel for the round trip between San Francisco and the Orient can be cut in half by the substitution of oil for coal. It is only a question of time when every vessel out of the ports of California will be compelled to use the new fuel.

PHOSPHATE ROCK AND PHOSPHORUS.

BY CHARLES C. SCHNATTERBECK.

The production of rock and pebble phosphates in the United States in 1903 was 1,570,228 long tons, valued at $4,993,912, as compared with 1,600,813 tons, valued at $5,041,362, in 1902. The output in 1903 contained approximately 508,324 tons available phosphoric acid, of which 226,433 tons, or 44.5 per cent, was shipped to domestic consumers, and 267,501 tons, or 52.6 per cent, to foreign superphosphate manufacturers; the balance is held at the mines for future consignment. It is noteworthy that the domestic manufacture of superphosphate is rapidly growing, and in six months in 1903 no less than 12 new factories were started. These are marketing a grade of superphosphate that analyzes from 13 or 14 to 16 per cent phosphoric acid, which sells at 55 to 65 cents per unit, or, say an average of $8.40 per ton.

AMERICAN PHOSPHATE PRODUCTION AND SHIPMENTS. (IN LONG TONS.)

Phosphates.	1902.				1903.			
	Production.		Shipments.		Production.		Shipments.	
	Quantity.	Value.	Domestic.	Foreign.	Quantity.	Value.	Domestic.	Foreign.
Florida, hard-rock (*a*)	476,110	$1,985,379	2,104	487,906	423,872	$1,801,456	2,352	465,520
Florida land pebble (*b*)	305,751	721,975	200,623	147,847	275,176	676,933	158,147	152 461
Florida, Peace River	7,070	8,385	7,070	......	65,655	82,069	65,655	......
Total Florida	788,931	$2,715,739	209,797	635,753	764,703	$2,560,458	226,154	617,981
North Carolina (*c*)	25,000	18,750	25,000	......	30,000	22,500	30,000	......
S. Caro., land rock (*b*)	254,556	773,005	241,822	60,803	280,012	840,036	271,685	33,170
S. Caro., river rock (*b*)	75,803	184,207			45,003	123,758		
Total S. Carolina	330,359	$957,212	....	......	325,015	$963,794	....	......
Tennessee (*d*)	454,078	1,341,161	277,552	105,530	445,510	1,434,660	284,456	134,108
Other States	2,445	8,500	2,445	......	5,000	12,500	5,000	......
Grand total	1,600,813	$5,041,362	756,616	802,086	1,570,228	$4,993,912	817,295	785,259

(*a*) Furnished by Messrs. Auchincloss Bros. (*b*) Production in 1902 reported by the United States Geological Survey; 1903, estimated. (*c*) In 1903 only 45 tons, valued at $500 were high-grade rock; the balance was low-grade mineral used mostly for macadamizing streets of Wilmington, N. C. (*d*) Production calculated by Commissioner of Labor, Statistics and Mines.

Prices during 1903 showed quite an improvement, as a result partly of the gradual centralization of control of the larger mines, particularly in Florida. Another good influence, tending to harden market prices, is the knowledge that no new deposits of high-grade mineral have been found in recent years, while the older ones are nearing exhaustion.

Exports and Imports.—A noteworthy fact is that the exports of 785,259 long tons of phosphates, containing approximately 267,501 tons phosphoric acid, in 1903, were mostly from Florida to Germany, and constituted over half of the total American output. In 1902 the exports of phosphates were greater than 1903 by 116,827 tons, or 14.5 per cent, and absorbed about one-third of the production. Imports of phosphates (phosphate rock, superphosphate, etc.) in 1903 amounted to 132,964 tons, valued at $679,112, free of duty, which is somewhat less than 1902. The phosphate rock came principally from the West Indies, and the superphosphate and other phosphatic materials, from Europe, chiefly from Belgium. It is interesting to mention that the imports of guano have greatly increased since the re-introduction of Peruvian manure; in 1903 the total imports were 21,007 tons, valued at $251,966, which compares with 8,407 tons, valued at $164,783 in 1902. Imports of all other fertilizers were valued at $2,353,496 in 1903, and at $1,725,330 in 1902.

PRODUCTION BY STATES.

There is a tendency to economize as regards the cost of production, partly because nearly one-half of the quantity mined annually is exported at an average ocean freight that is equivalent to about 50 per cent of the f. o. b. price of phosphate rock. Doubtless the approaching exhaustion of certain well-known deposits, and the likelihood that others of equal value will not be found, has also helped to inaugurate a change of policy in operating the mines. Then again the declared affiliation of the larger mining interests, particularly in Florida, has advanced the idea of building new railroads to carry the phosphate to an independent export port, and thus facilitate competition in foreign markets. The labor situation at the mines is receiving increased attention, and an attempt has been made in the past year to replace the negro by white labor, so as to be assured of a regular supply. Of course, the difference in wages will prevent some mines, now working on a small margin of profit, from making the change in their employees. Prospects for a good year in 1904 are promising, as a large part of the output of high-grade mineral has been sold in advance at better prices than 1903.

Arkansas.—Practically the entire production, 5,000 tons in 1903, was consumed locally by the Arkansas Phosphate Co., which has increased the capacity of its superphosphate plant at Batesville. The phosphate rock mined carries from 50 to 80 per cent bone phosphate of lime. The completion of the railroads touching the phosphate deposits will greatly facilitate the development of a remunerative industry, and it seems likely that Arkansas superphosphate will be introduced in Eastern markets in the near future.

Florida.—The statistical position in this, the most important phosphate mining center in the world, showed a marked change in 1903 as compared with 1902, owing principally to the smaller exports, notably to Germany. In 1903 the output totaled 764,703 long tons, as against 788,931 tons in 1902. There was shipped in 1903 844,135 tons—617,981 tons, or 73.2 per cent, being for foreign consumption, and 226,154 tons, or 26.8 per cent, for domestic markets. The hard-rock shipments were 467,872 tons, equivalent to 55.4 per cent of the total; land pebble, 310,608 tons, or 36.8 per cent, and Peace River pebble, 65,655 tons, or 7.8 per cent.

FLORIDA PHOSPHATE SHIPMENTS. (IN LONG TONS.)

Destination.	Hard-Rock.		Land Pebble.		Total.	
	1902.	1903.	1902.	1903.	1902.	1903.
Australia	......	......	4,996	3,000	4,996	3,000
Austria	14,310	9,000	3,300	......	17,610	9,000
Belgium	41,245	35,400	......	......	41,245	35,400
Denmark	2,750	11,870	......	......	2,750	11,870
France	3,950	5,865	39,837	38,755	43,787	44,620
Germany	264,550	246,824	18,450	27,940	283,000	274,764
Great Britain	51,348	43,271	24,530	28,526	75,878	71,797
Holland	77,176	73,280	6,600	......	83,776	73,280
Italy	16,363	18,542	34,699	36,430	51,062	54,972
Japan	......	......	......	2,700	......	2,700
Norway and Sweden	10,250	15,862	15,435	15,110	25,685	30,972
Spain	5,964	5,606	......	......	5,964	5,606
Exports	487,906	465,520	147,847	152,461	635,753	617,981
Domestic	2,104	2,352	200,623	158,147	202,727	160,499
Total	490,010	467,872	348,470	310,608	838,480	778,480
Peace River Pebble, domestic	......	......	......	......	7,070	65,655
Grand total	490,010	467,872	348,470	310,608	845,550	844,135

Prices for 77 to 80 per cent rock were well maintained during 1903, averaging \$6.25 per long ton, f. o. b. Florida or Georgia ports in January, February and March; \$6.75 in April; \$7.08 in May; \$7.25 from June to September; \$7.28 thereafter, making the year's average \$6.95. Quotations for deliveries at European and British ports showed an advance, averaging \$9.78 in January and February; \$9.90 in March; \$10.86 in April and August; \$11.44 in May; \$11.58 in June; \$11.70 in July; \$11.13 in September, and \$11.12 in the closing months, making an average for the year of \$10.86, which is equivalent to about 7d. per unit of tribasic phosphate of lime. On exports there were paid for freight from Florida or Georgia ports 10s. 3d.@15s. 6d. (\$2.46@\$3.72) to Continental markets; 13s.@16s. (\$3.12@\$3.84) to Baltic; 12s. 6d.@13s. 6d. (\$3@\$3.24) to the United Kingdom, and 14s.@15s. 6d. (\$3.36@\$3.72) to the Mediterranean. The foremost feature is the centralization of control in a few hands of the larger hard-rock and land pebble mines, either by direct purchase or consolidation agreement. Second in importance is the increasing use of dredges in hard-rock mines that have touched water-level—a policy suggested by the fruitless exploration for new deposits. Incidentally, the question of economic transportation from mines to tidewater has received careful consideration, particularly by exporters of hard-rock who have been accustomed to pay rather high freight rates to the railway corporation that has for years controlled this traffic. Several independent railroads have been chartered as a result of the successful operation of the Dunnellon Phosphate Company's line which opened Port Inglis, and made it in 16 months the second largest export point for hard-rock. This advantage in transportation claimed by the larger mining companies naturally created discontent among the other shippers who patronized the regular railroads. The result was that after long argument the State Railroad Commissioners ordered that a uniform rate of 1c. per short ton-mile from mines to the seaboard be charged after January 15, 1904.

Hard-Rock.—One of the surprising features is the continued excess of shipments over production, and the consequent depletion in stocks at the end of the year. Thus in 1903 the production amounted to 423,872 tons, while the shipments, nearly all export, were 44,000 tons greater. Another interesting point is that there were in 1903 only 20 operators in the field, who owned 60 plants, of which 48 were working, 7 idle, and 5 building or moving. Of the 20 operators, three were companies that controlled 37 plants, or over half the total. This is further evidence that the consolidation fever is rampant. Following are the statistics for the hard-rock industry, the quantities being in long tons of 2,240 lb., as reported by Auchincloss Bros.:

Year.	Operators.	Plants in Hard-Rock Region.				Production.	Shipments.	Stocks at end of year.
		Building or Moving.	Idle.	Working.	Total.			
1900....	50	5	22	51	78	458,118	348,556	211,700
1901....	41	3	29	40	72	400,380	424,130	187,590
1902....	32	3	17	50	70	476,110	492,610	171,450
1903....	20	5	7	48	60	423,872	467,872	127,450

The cost of working the mines is steadily increasing. Labor is more expensive, fuel dearer, as wood must be hauled long distances, and the older mines are experiencing difficulty in producing merchantable rock. True, electricity as a motive power has been tried with success, the employment of some 10 or 11 dredges is saving labor, and independent railroads are minimizing the cost of transportation. During the year J. Buttgenbach & Co., large exporters, chartered the Standard & Hernando Railroad Co. to run from Standard (on the Seaboard Air Line) to Hernando, a distance of 23 miles, and then by a spur to the mouth of the Withlacoochee River. The Dutton Phosphate Company, representing the consolidation of a number of plants, and the heaviest exporter, has obtained control of the Jacksonville & Southwestern Railroad. The Camp Phosphate Co., also an important exporter, built several barges to transport rock down the Withlacoochee River to the Gulf of Mexico.

Land sales were few in 1903, but good prices ruled. Among the deals was one made to W. C. Hathcock for a large deposit of rock underlying the town of Dunnellon. Speculative buying has practically died out.

Land Pebble.—The consolidation by purchase of the plants owned by the Prairie Pebble Phosphate Co., the Land Pebble Phosphate Co., the Phosphoria Phosphate Co., and the Florida Engineering Co., Mr. Joseph Hull, of Savannah, Ga., has acquired control of the major part of the land pebble phosphate trade. At the opening of the year there were eight plants operating, and the total production for the twelve months was 275,176 long tons, which is somewhat less than 1902 in consequence of the severe storm in August. Shipments in 1903 were 310,608 tons, of which 152,461 tons, or 49 per cent, went abroad, chiefly to France and Italy, and 158,147 tons, or 51 per cent, was for domestic consumption, principally in Maryland and New Jersey. It is noteworthy that the exports in 1903 show an increase of 4,614 tons as compared with 1902, while domestic trade fell off 42,476 tons, making the total net decrease 37,862 tons, or nearly 11 per cent. An interesting shipment was a cargo of 2,700 tons from Tampa to Yokohama, Japan, paying an ocean freight of 20s. ($4.80), which is more than the f. o. b. price paid for the phosphate.

There has been satisfactory improvement in the market prices of land pebble, which analyzes from 67 to 73 per cent tribasic phosphate of lime, and competes abroad with the African phosphates. The average price f. o. b. Tampa was $3.13 per ton in January, February and March; $3.38 in April; $3.57 in May; $3.63 from June to September, and $3.69 thereafter, showing a year's average of $3.59. In European and British markets prices were well maintained, averaging $6.83 in January and February; $7.08 in March; $7.88 from April to December, a total for the year of $7.64, or $4.05 more than the f. o. b. price. This difference is accounted for by the fluctuation in ocean freight rates, selling commissions, and other charges incident to delivery to foreign consumers.

Peace River Pebble.—This region has been actively developed by the American Agricultural Chemical Co., which now owns all the shares of the Peace River Phosphate Mining Co. The entrance of the Northern fertilizer combination into the phosphate mining industry was the result of a change in the economic management of its manufacturing business. In 1903 shipments totaled 65,655 tons, all consumed by the American Agricultural Chemical Co. This quantity compares with 7,070 tons shipped in the preceding year, when the plant was being rebuilt on a modern scale. In explanation of the fact that this is the only operator in the field, it is intimated that much expense is incurred in producing the phosphate, owing chiefly to the frequent handling before it is marketed. The American Agricultural Chemical Co. maintains about 50 miles of railroad tracks to transport the phosphate from its dredges to the driers, then to the sheds and subsequently to barges which carry it to Punta Gorda, the deep water shipping port. Peace River pebble analyzes from 58 to 63 per cent bone phosphate of lime, and prior to the acquisition of the only plant by the fertilizer combination, quantities were exported to Europe and sold at a little less than land pebble.

Mississippi.—Discoveries of phosphate pebbles analyzing about 10 per cent phosphoric acid are reported in Oktibbeha county. The nodules were found in a marl, which also contained much phosphoric acid. Further prospecting is necessary before the deposit can be considered of economic importance.

North Carolina.—The Castle Haynes mines, now worked by individuals, produced about 30,000 tons in 1903, which was used mostly for macadamizing the streets of Wilmington. This phosphate analyzes 18 to 24 per cent bone phosphate of lime, 32 to 45 per cent sand, 10 to 30 per cent carbonate of lime, and 15 to 40 per cent iron and alumina. Small quantities have been used as a fertilizer, but this use is necessarily limited by the low content of phosphoric acid, and high percentage of iron and alumina.

South Carolina.—Dredging on Coosaw river, at one time a very profitable business yielding high royalties to the State, has fallen off, owing to the low market price as a result of competition with Florida and Tennessee phosphates. In the fiscal year ending November 30, 1903, the production of river rock totaled only 45,003 long tons, little more than half the quantity reported in the previous twelve months. Shipments were 60,536 tons, leaving stocks on hand at mines on November 30, 1903, 16,810 tons, which compares with 37,314 tons in 1902. The royalties paid on shipments in 1903 amounted to $15,134, against $27,292 in 1902. Producers in 1903 were the Coosaw Phosphate Mining Co., Central Phosphate Co., Beaufort Phosphate Co., the Empire mines, controlled by the Virginia-Carolina Chemical Co., and the Stono mines. It is worthy of remark that this depreciation in river mining necessitated the abolition of the office of State Phosphate Inspector in August, 1903. Hereafter the commissioners will attend to the work, although it has been suggested that the State geologist be made a member of the board for the purpose of verifying the reports made by the mining companies when declaring their royalties. Land rock mining is controlled largely by the Southern fertilizer combination which owns the stock of the Charleston Mining and Manufacturing Co. A good quantity is also converted directly into commercial fertilizers by various other concerns, so it becomes almost impossible to give accurate statistics of production. It is estimated, however, that the output of land rock in 1903 was 280,012 tons, which is 10 per cent more than 1902. This would make the total phosphate production in the State in 1903, 325,015 tons, which, compared with 1902, shows a decrease of 15,344 tons, due to the heavy reduction in river rock output. Exports in 1903 were approximately 33,170 tons, principally to Great Britain, which is considerably less than 1902.

Prices on vessel at Ashley River, S. C., ruled steady throughout the year at an average of $3.25 per ton for land rock, and $2.88 for river rock. For export, prices fluctuated in European markets, averaging $5.83 per ton in January, February and April; $5.66 in March; $6.08 in May, September, October, November and December; $6.13 in June and August; and $6.24 in July; making the average for the year $6, or say 5¼d. per unit for 55 to 60 per cent rock. The ocean freight from Coosaw to European ports varied from 10s.@ 13s. 9d. ($2.40@$3.30), leaving a small margin of profit to exporters.

Tennessee.—Three factors affected the production in 1903, namely, an inadequate supply of labor, intermittent wet weather, and a limited number of cars for transporting the phosphate to market. Still the output during the year amounted to 445,510 long tons, while shipments, principally to domestic consumers, amounted to 418,564 tons. Exports, mostly through Pensacola, Fla., were 134,108 tons, which is somewhat more than 1902. These exports were made to Italy, France, Belgium, Great Britain and Germany. Stocks at mines on December 31, 1903, were 84,841 tons, as against 57,895 tons at the end of 1902.

Better prices were obtained in 1903. At Mt. Pleasant the f. o. b. quotations for 78 to 82 per cent export rock averaged $3.38 per ton from January to May; $4 in June; $4.13 thereafter, making the average for the year $3.93. The ocean freight to European ports varied from 12s. 3d.@15s. 9d. ($2.74@$3.78). The c. i. f. prices averaged $8.97 in January and February; $9.22 in March; $10.62 in April, and $10.80 thereafter, making an average for the year of $10.35. This is about 50c. per ton less than was received for Florida high-grade rock, owing principally to the higher percentage of iron and alumina in the Tennessee phosphate. Prices for domestic rock were steady, averaging $3@$3.38 per ton for 78 per cent grade, f. o. b. Mt. Pleasant; $2.88@$3.50 for 75 per cent; $2.55@$3.08 for 73 to 74 per cent; $2.18@$2.83 for 70 to 72 per cent.

Development work in Maury and Hickman counties was particularly energetic, and in the early spring about 5,000 miners were at work, of whom 3,000 were employed in the Mt. Pleasant district. An attempt was made to introduce white labor with a view of lessening the number of negro laborers.

Numerous small land sales have been reported, especially in the Springhill section of Maury county, and an impetus to mining has also been given by new discoveries.

An incident of interest is the exportation of superphosphate from this State to Europe and Canada, a trade that promises to grow.

The composition of the different grades of phosphate mined in the State, as given by the Chief Mine Inspector, is as follows:

Phosphate.	Calcium Phosphate.	Iron and Alumina.	Moisture.
	Per cent.	Per cent.	Per cent.
Maury Co., brown rock, export	78—82	2.75—4.00	0.05—2.00
Maury Co., brown rock, domestic	72—78	2.75—4.00	0.05—3.00
Hickman Co., blue rock	62—70	2.00—3.00	0.00—3.00
Perry Co., white rock	78—83	3.00	....
Decatur Co., white rock	68—74	3.00	....

The small quantity of iron and alumina in the blue rock in Hickman county more than offsets the low contents of calcium phosphate and places it in direct competition with the brown rock mined in the Mt. Pleasant field that is used for domestic purposes.

The mining in the blue-rock field is all underground, and is carried on by tunneling. The thickness of the seam, says the Chief Mine Inspector, is from 14 to 48 in. The explosives used in mining this rock necessarily cut some figure in the cost of production, estimated at about 30c. per ton. Mining for the brown rock is all surface work, the overburden being from nothing to 30 ft. The thickness of the vein varies from 2 to 15 ft.

MINING IN FOREIGN COUNTRIES.

New discoveries of phosphate deposits have been reported, but with few exceptions the grade of mineral has not proved satisfactory. The distance from economic transportation to consuming markets also often decides against the development of new deposits, especially when the grade of phosphate is less than 60 per cent bone phosphate of lime, or carries more than 3 per cent iron and alumina. In certain instances an extensive deposit of so-called low-grade phosphate where its market price would not compensate the cost of transportation, it has been found expedient to convert the rock locally into superphosphate for domestic consumption.

It is noteworthy to mention that prospecting is most energetic on the African continent, and the extension of the railways has encouraged active development of the Tebessa and Tunis deposits. The Polynesian islands, it is interesting to chronicle, produce the highest grade phosphate mined anywhere on the globe, and what is equally surprising, the ocean freight to European consuming markets represents over half the c. i. f. price of the phosphate. Still the shipments are growing.

Africa.—Rapid progress is being made in the development of phosphate beds in Algeria, Tunis and other promising sections of the African continent, as a result of the increased demand from the European markets. Nearly all the phosphate produced is exported, and in 1903 total shipments were 658,492 metric tons, which compares with 533,426 tons in 1902, showing an increase of 125,066 tons, or 23.4 per cent. The shipments in 1903 were distributed

AFRICAN PHOSPHATE SHIPMENTS IN 1903. (IN METRIC TONS.)

Destination.	Boné (Tébessa.)	Bouglies. (Tocqueville)	Sfax. (Tunis.)	Total Shipments.	
				1903.	1902.
Algeria	2,519	......	......	2,519	4,514
Austria	9,930	......	1,570	11,500	8,056
Belgium	5,390	1,525	16,840	23,755	5,120
France	60,991	8,970	129,659	199,620	185,225
Germany	44,315	923	34,968	80,206	80,348
Great Britain	77,805	8,432	82,424	168,661	111,435
Holland	19,390	......	15,286	34,676	31,630
Italy	28,599	......	70,985	99,584	83,346
Norway and Sweden	......	......	2,539	2,539	3,320
Portugal	4,662	......	......	4,662	5,302
Roumania	3,000	......	3,300	6,300	2,200
Russia	9,750	......	400	10,150	5,400
Spain	11,170	500	2,650	14,320	7,530
Total	277,521	20,350	360,621	658,492	533,426

as follows: Tunis, *via* Sfax, 360,621 tons, equivalent to nearly 55 per cent of the total; Tébessa, *via* Boné, 277,521 tons, or 42 per cent; Tocqueville, *via* Bouglies, 20,350 tons, or 3 per cent. France, Great Britain and Germany, in the order named, were the largest purchasers. The shipments from Tunis, begun in 1899, are made entirely by the Gafsa Phosphate Co., which marketed during the five years to 1903 a total of 1,039,538 tons. In 1904 the shipments by this company are expected to total 400,000 tons, which compares with 360,621 tons in 1903. In the Tebéssa region there are three operators, who from the beginning of the industry to the end of 1903 have reported shipments as follows: Constantine Phosphate Co., 948,746 tons; Dyr Phosphate Co. (Crookston Brothers), 710,831 tons; Société Française, 289,290 tons, making a total of 1,948,867 tons.

The exports given above were made at ocean freight rates of 6s. 6d.@8s. 6d. ($1.56@$2.04) from Boné, and 7s.@10s. 6d. ($1.68@$2.25) from Sfax. The average monthly prices for rock delivered in European or British markets were equivalent to $6.14@$7.88 per ton for 63 to 70 per cent grade, and $5.36@ $6.75 for 58 to 63 per cent.

Much attention is being given to the exploitation of new deposits, and some rich discoveries are reported in Tunis. Here, in the district of Uarfa-Tarf, about 50 km. west of Gafsa, a Belgian company uncovered six seams of good rock, three of which had a total thickness of nearly 5m., and show analyses of 63 per cent tribasic phosphate of lime, 14 to 20 per cent carbonate of lime, and 1.5 per cent iron and alumina. In Algeria, new deposits at Zailou, Sidi-Aissa, Seghvali and Khendek Zoungal, in the Commune of Nedromah, province of Oran, are to be developed by the Zailou Phosphate Co., organized early in 1904 with a capital of £100,000. The Rhiras deposits owned by L. Chateau have consolidated with the Tocqueville Phosphate Co., both properties now being worked by the Union des Phosphates de Tocqueville et des Rhiras, of Paris.

Australia.—Although discoveries of phosphate rock are frequently reported, and picked samples analyze high, the deposits generally prove of little commercial value owing to the excess of iron and alumina present. Still quantities of the mineral are mined both for export and home consumption. In South Australia large superphosphate works are situated at Wallaroo. In this State deposits of phosphate have recently been uncovered in the Kapunda and Burra districts, and on Yorke Peninsula another bed has been found which is similar in mode of occurrence to those at Clinton, Bright and Belvidere. Samples of the Yorke phosphate analyzed from 70.07 to 82.95 per cent tricalcic phosphate. The phosphate occurs in boulders and lumps, and is associated with argilaceous, arenaceous, and calcareous beds. In New Zealand active work is being done at the mines in the Clarendon and Milburn districts, Otago.

Belgium.—Phosphate rock and phosphatic chalk deposits occur in the vicinity of Mons and Liege. In 1902 the production of the former was 135,850 metric tons, valued at $297,848, and of the latter, 315,200 cu. m., valued at

$282,920. Both minerals are rather low-grade, and besides being converted into superphosphate for domestic consumption and export, are also used as fillers for fertilizers in America and elsewhere. In European markets Liege phosphates sold during 1903 as follows: 60 to 65 per cent tricalcic phosphate, and 3 per cent iron and alumina, $6.89@$7.96 per ton; 55 to 60 per cent, and 3.5 per cent, $6.12@$6.34; 50 to 55 per cent, and 4 per cent, $4.39@$4.69; 45 to 50 per cent, and 4.5 per cent, $3.52@$3.61; 40 to 45 per cent, and 5 per cent, $2.66@$2.75.

Canada.—In 1903 the output of apatite, mined in the counties of Wright and Labelle, near Ottawa, was 1,206 metric tons. This is somewhat more than was reported in 1902. The high-grade ore (80 per cent) is converted into phosphorus, while the low-grade is used as a fertilizer.

Dutch West Indies.—In the fiscal year ending September 30, 1903, the Aruba Phosphate Co., operating on a concession from the Dutch Colonial Government, shipped 24 cargoes, principally to Great Britain. The export duty was 4,115.43 florins ($1,654.40). Five more vessels were dispatched by the end of 1903.

Egypt.—As yet no particular development work has been done on the phosphate beds occurring on the land of the Egyptian Mines Exploration Co., although the mineral analyzes over 72 per cent bone phosphate of lime, and less than 1 per cent iron and alumina.

France.—Approximately one-half of the phosphate rock produced annually comes from the department of Somme, where the more important mines are situated in the districts of Peronne, Marcheville and Beauval. Next in importance are the departments of Aisne, Pas-de-Calais, Meuse and Oise. The total output in 1902 was 543,900 metric tons, which compares with 535,676 metric tons in 1901. Imports, principally from Algeria, in 1903, were 427,177 metric tons, as against 304,577 tons in 1902, and 272,789 tons in 1901. Exports in 1903 were 72,786 tons; in 1902, 62,309 tons; in 1901, 81,257 tons. The imports of superphosphates in 1903 were 87,101 metric tons; in 1902, 67,076 tons; in 1901, 71,208 tons. Exports in 1903 were 164,201 tons; in 1902, 138,125 tons; in 1901, 99,703 tons. The phosphates from Somme, containing 70 to 75 per cent bone phosphate of lime and 3 per cent iron and alumina, sold in European markets in 1903 at an average of $9.92@$10.45 per ton. Early in the year 65 to 70 per cent grade, carrying 4 per cent iron and alumina, was quoted at $7.18@$7.44, and 60 to 65 per cent, 5 per cent iron and alumina, $5.70@$5.94. Bordeaux phosphates, analyzing 60 to 65 per cent bone phosphate of lime, sold at $7.48@$7.60 per ton, and 55 to 60 per cent grade, $6.34@$6.45.

Japan.—The consumption of superphosphate showed a marked improvement until the hostilities with Russia affected agricultural pursuits in this country. Most of the phosphate used is imported from the Pacific Islands, though several cargoes have also come from America and Australia. The sulphuric acid for converting the phosphate into a fertilizer is either made locally from domestic sulphur, or is imported from Great Britain or Germany. Extensive guano deposits were worked on Tori Shima island until August, 1902, when a volcanic eruption devastated the region. Phosphate rock averaging about 10 per cent phosphoric acid was discovered in 1903 at the village of Kamo, near Shima. The deposit is situated about 1.5 to 1.75 miles from the port of Funatsu, on the bay of Toba. It is estimated that it would cost 3.45 yen ($1.72) per ton to mine and deliver the phosphate to Funatsu. Some difficulty will be experienced in separating the phosphate from the manganese, and until a suitable method has been found, development work will be postponed.

Norway.—The apatite mines at Bamle, near Kragero, producing annually between 1,500 and 2,000 metric tons, are now controlled by the Franco-Norwegian Apatite Mining Co. The phosphate is of high grade and is exported at better prices than its competitors in the European markets.

Polynesian Islands.—The phosphate industry in the Christmas, Ocean and Pleasant islands has been handicapped by the variable weather and high ocean freight rates to leading consuming markets. British capital is largely interested in these deposits, the mines being worked on long time leases. New discoveries are reported on an island to the northwest of the Solomon group, and the mineral showed about 86.15 per cent bone phosphate of lime and only 0.68 per cent iron and alumina.

In 1903 shipments from Christmas island amounted to 67,527 long tons, which compares with 57,744 tons in 1902, and 46,898 tons in 1901. The output for 1904, calculated at 125,000 tons, has been sold in advance at good prices. Ocean island reported exports in 1903 of 53,000 tons, which makes a total since 1900, when work began, of about 103,000 tons. In 1904 the production will likely be 100,000 tons, as orders for this quantity have already been booked.

CHRISTMAS ISLAND PHOSPHATE SHIPMENTS, IN LONG TONS.

Destination.	1901.	1902.	1903.
Australia	......	3,350	2,200
Germany	21,473	25,390	30,322
Great Britain	5,700	5,625	......
Italy	......	......	3,250
Japan	15,725	13,054	15,190
Sweden	4,000	10,325	16,565
Total	46,898	57,744	67,527

The c. i. f. prices for 80 to 85 per cent Christmas rock, in 1903, averaged $12.13@$12.99 per ton, while the ocean freight to Baltic ports was 27s.@29s. ($6.48@$6.96) per ton. Ocean island phosphate, analyzing 82 to 88 per cent, and guaranteed to contain less than 1.5 per cent iron and alumina, sold in Europe at an average of $13.60@$14.45 per ton.

On Christmas island employment is given to about 700 Chinese coolies. At present the phosphate is taken from the surface to a depth of about 12 in., and is transported by trams to lighters having a capacity of 10 to 15 tons each. Subsequently the phosphate is loaded on vessel by derrick, and is then ready for export.

Spain.—A very fine quality of phosphate has been discovered in quantity on the northern slopes of the Pyrenees, between the towns of Seron and La Bastide. In color the phosphate rock is black, and a French company has been formed to exploit the deposits.

THOMAS OR BASIC SLAG.

The demand for basic bessemer steel slag in agriculture is increasing in Europe, where it is principally produced in Germany, France and Belgium. Great Britain also produces some, but America, being well supplied with phosphates, has not encouraged the slag fertilizer industry. Analyses of slag commonly used in France showed a content of 14 to 19 per cent phosphoric acid, and 41 to 52 per cent lime. It is contended that slag, owing to the free lime which it contains, is well adapted to acid soils which contain the largest amount of uncombined lime. Experience has shown that slag that analyzes high in calcium, low in magnesium, and is nearly free from oxides of iron and manganese, and with the oxygen ratio of from 0.67:1 to about 1:1, is most desirable.

To encourage investigation into the increase of fertility of soils by the action of bacteria under the influence of mineral manures, especially of manuring with basic slag, prizes of 40,000 marks have been offered in 1903 by the Verein der Thomasphosphatfabriken at Berlin, Germany.

PHOSPHORUS.

Consumption is increasing in America, and in addition to the domestic production, there is imported annually between 30,000 and 40,000 lb., upon which a duty of 18c. per lb. is levied. Quotations at New York in 1903 ranged from 45c. to 70c. per lb., according to brand.

The General Chemical Company, a large domestic manufacturer, has acquired the United States patent (733,017) of Robert K. Duncan for an apparatus for making phosphorus electrically. The electric furnace used consists of a decomposition chamber for treating the phosphide with water, a storage tank for the phosphide evolved, a drying chamber connected with the storage vessel, a heating chamber for decomposing the phosphide, and a suitable receiver connected with the heating chamber for the products of decomposition.

A new variety of phosphorus, non-poisonous and an efficient substitute for white phosphorus in the manufacture of matches, has been discovered by Prof.

Schenck, of Marburg, Germany. It is stated that the new phosphorus is bright red in color, and is prepared by heating a 10 per cent solution of white phosphorus in phosphorus tribromide to boiling.[1] The product is converted by ammonia into a black substance which again changes to red phosphorus when boiled with water or acid. Matches prepared from the new material show good powers of resistance to the influences of moisture and climate and are in every way satisfactory. As difficulties have been experienced in the use of the ordinary amorphous red phosphorus in the preparation of non-poisonous matches it is believed that the new variety will be generally adopted for this purpose.

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[1] *Journal Society Chemical Industry*, November 30, 1903.

QUICKSILVER.

BY D. H. NEWLAND.

The production of quicksilver in the United States during 1903 amounted to 37,123 flasks of 76.5 lb., valued at $1,564,734, as compared with 34,804 flasks, valued at $1,515,714 in the previous year. Of the total, California contributed 32,094 flasks, against 29,552 in 1902, and Texas 5,029 flasks, against 5,252 in 1902. The production was the largest recorded since 1883. The Black Butte district of Oregon made no output last year.

PRODUCTION AND EXPORTS OF QUICKSILVER IN THE UNITED STATES.

Year.	Production.			Exports.		
	Flasks.	Met. Tons.	Value.	Flasks.	Met. Tons.	Value.
1898	30,493	1,058	$1,109,945	12,830	445	$440,587
1899	28,879	993	1,155,160	16,518	573	609,586
1900	27,855	967	1,288,851	10,172	353	425,812
1901	29,727	1,031	1,382,305	11,219	389	475,609
1902	34,804	1,208	1,515,714	13,247	459	575,099
1903	37,123	1,288	1,564,734	17,575	610	719,119

The imports of quicksilver during the past six years were as follows: 1898, 81 lb. ($51); 1899, 131 lb. ($83); 1900, 2,616 lb. ($1,051); 1901, 1,441 lb. ($789); 1902 and 1903, *nil.*

Prices.—The average monthly prices of quicksilver at New York and San Francisco during 1903 are given in the subjoined table:

Month.	New York.	San Francisco.		Month.	New York.	San Francisco.	
		Domestic.	Foreign.			Domestic.	Foreign.
January	$47.75	$45.50	$43.50	August	$47.50	$44.50	$42.00
February	47.00	45.50	43.00	September	47.50	44.75	42.00
March	47.00	45.00	42.50	October	47.50	44.75	41.87½
April	47.25	44.50	42.00	November	46.75	44.00	41.50
May	47.50	44.50	42.00	December	46.50	44.00	41.50
June	47.50	44.50	42.00				
July	47.50	44.50	42.00	Averages	$47.27	$44.67	$42.15

California.—The quicksilver industry of California experienced a slight improvement during 1903. This was apparent in the re-opening of some of the old mines and in the increased interest taken in the industry by local capital. The old mines appear to be holding their own, and a few, like the New Idria, are increasing their output. In Colusa county, at the Manzanita mine, experiments have been carried out which demonstrate that wet concentration of quicksilver ores is not only feasible but profitable. In Lake county, the Silver Bank and Abbott mines, belonging to the Empire Consolidated Quicksilver Mining Company, have suffered from litigation. The Great Western Company is continuing its regular output and developing its mine for future working. The Standard Company still operates the Bouillon mine. At the Oathill mines, in Napa county, one of the two furnaces has been entirely renovated. The Corona and Twin Peak mines have both been active. In the Knoxville district, the old Redington mine, now called the Boston, has been re-opened and is a steady producer. In San Benito county, the New Idria mine seems to have entered upon a new era of prosperity. It is producing about 160 tons per day and has a large ore reserve. The re-opening of the Cerro Benito mine has been undertaken and the old furnace rebuilt. In San Luis Bispo county there has been considerable activity, particularly in the Karl and Oceanic mines. There are a number of smaller mines in this county which have undergone more or less development during the year. In Santa Clara county the new Almaden continues to be a large producer. At the Santa Teresa mine a new Scott furnace is in course of erection. The Summit mine has recently passed into the hands of a corporation, and a Scott furnace is being erected. In Sonoma county a number of old mines have been re-opened, including the Sonoma and the Crystal mines. The Cloverdale has been operating its 7-ton furnace steadily. In Trinity county the Altoona property has produced some quicksilver from the old dumps. The Boston & Integral Company has been steadily at work developing its property.

The Ætna Consolidated Quicksilver Mining Company, which made no production in 1902, mined 5,561 tons of ore in 1903, producing 290 flasks of quicksilver, an average yield of 0.2 per cent per ton of ore. There was a net loss of $23,646 in the year's operations. The ore shoot narrowed and pinched out, and the furnace has closed down. The Napa Consolidated Quicksilver Mining Company produced 37,111 tons of ore in 1903, yielding 4,850 flasks, the average recovery being 0.5 per cent. The total receipts were $195,940 and the expenses $185,596. During the year 8,715 ft. of drifts and tunnels were run, but no new large orebodies of high grade developed. The Boston Quicksilver Mining Company treated 23,774 tons of ore in 1903, securing 1,950 flasks of quicksilver, showing a content of 0.3 per cent of metal. The loss on the year's business was $28,742. Although 3,672 ft. of development work was done, no new orebodies were discovered. The New Idria Quicksilver Mining Company mined and treated 52,499 tons of ore, producing 8,150 flasks of quicksilver, showing an average of 0.59 per cent of metal. The development work consisted of 551 ft. of drifting in the Idria mine and 1,298 ft. in the San Carlos. The total receipts were $326,258, and the net earnings $184,909. A dividend of $150,000 was paid, leaving a surplus of $136,185. The annual report of the company states that all the levels are yielding good ores.

Oregon.—According to W. B. Dennis[1] the occurrence of cinnabar has long

1 The Engineering and Mining Journal, October 10, 1903.

been known in a number of localities in the western part of Oregon. Until recently, however, very little attention has been paid to the deposits, and up to the present time only one property has been developed to any extent. The existence of cinnabar in Oregon first became known through the working of placer mines in Jackson county. A heavy reddish sand was found in the sluice boxes and was frequently a source of great annoyance. When it became known that the red sand was cinnabar, several attempts were made to utilize it by distillation in common gold retorts, and miners were sometimes able in this way to distill sufficient mercury for their own use.

About 35 years ago cinnabar was discovered near the head of Little Applegate river, in the southern part of Jackson county. In 1871 a crude furnace was erected to reduce the surface ores. For a short time the local demand of the placer miners was thus supplied, but the furnace was soon abandoned. In 1899 the claims were relocated, and in 1901 the property was acquired by a Montana company, which has since done considerable development work. Other claims have been located in the same region and are being developed. The cinnabar of this district occurs in very fine crystals, saturating a gangue of granular calcite. The veins have nearly a north and south strike, and dip at an angle of about 48° west. They lie in near proximity to granite. The footwall is a decomposed arkose, while the hanging is a dark massive serpentine, which passes at a short distance into carbonaceous shales and slates.

In the region of Evans creek, a tributary of the Rogue river, about 20 miles northeast from the town of Gold Hill, there are outcroppings of cinnabar which extend some 6 miles from the Meadows to Ramsey cañon, the belt being about three-quarters of a mile wide. Four prospects have been opened to some extent, but sufficient work has not been done to demonstrate the value of the deposits. Further north, on Calapooia creek, in Douglas county, 8 miles west of Oakland, two quicksilver mines, known as the Bonanza and Nonpareil, were opened some years ago. At one of these a small furnace was built, but it was operated only for a short period. No attempt is being made at present to work the mines. In the extreme northern part of Douglas county, on the branch of Elk creek, is located the Elkhead mine. This property is credited with having produced quicksilver to the value of about $30,000. Some 15 years ago the surface ore was quarried and treated in a coarse ore-furnace. In 1895 a 10-ton Scott continuous furnace was built and operated for a short time on the screenings of the old furnace. The lack of ore reserve caused the mine to be shut down, and it is now idle.

The Black Butte quicksilver district is situated in the southern part of Lane county, about four miles east of the Elkhead mine. The district is about four miles long and two miles wide, and lies on the northern slope of the Calapooia mountains, near the head of the coast fork of the Willamette river. The district is controlled by two companies—a private company, of Portland, Oregon, owns about 1,000 acres, including the Bald Butte and Cinnabar Butte mines;

the Black Butte Quicksilver Company controls practically the balance of the district. The latter company, about five years ago, installed a Scott continuous furnace, having a capacity of 50 tons per day, and since that time it has done a large amount of underground development work. The ore in the Black Butte district occurs in a large vein as a cinnabar-bearing volcanic breccia. The vein outcrops along the ridge of Black Butte mountain, and is exposed for a distance of 7,500 ft. In common with all other quicksilver deposits of importance, the ores consist mainly of the red sulphide of mercury or cinnabar, although the black sulphite meta-cinnabar and a little native mercury have also been encountered. The main fissure of Black Butte mountain is 400 ft. wide. The richest ores occur along minor walls within this lode. As a rule, the stoping widths of rich ore range from 7 to 20 ft., but there are large areas of lower grade ore, which would be available for treatment under the system of averaging a large tonnage. Besides the main fissure, three others of importance have been discovered and opened up sufficiently to insure a large supply of ore. Two of these openings have been made at a depth of 1,300 and 1,600 ft., respectively, below the apex of the mountain. They have shown the presence of cinnabar at the levels.

The occurrence of rich ores, assaying from 40 to 70 per cent mercury, allowed the early exploiters of the Black Butte mine to expect the discovery of great bonanzas, such as have been found at New Idria and New Almaden, in California; but while similar orebodies may exist, none has been encountered as yet, and the present management has confined its attention to the development of the immense masses of average and lower grade ores. A conservative estimate of the district from a commercial standpoint, so far as present development shows, must deal with the question of handling great bodies of low-grade ore. The profitable working of the deposits calls for extensive reduction works, modern appliances and operations on a large scale, for which the local conditions seem to be peculiarly favorable.

Texas.—A discovery of quicksilver deposits in Texas was reported during the year. The locality is southeast of the Chisos mountains, within six miles of the Rio Grande. According to W. B. Phillips[2] the deposits show a close resemblance to those of the Terlingua district, which have been described in previous volumes of THE MINERAL INDUSTRY. The country is limestones and shales of Cretaceous age, associated with intrusions of igneous rocks. The deposits so far as explored lie in limestone, on the side of a limestone ridge, which has been cut by rhyolite. This ridge forms the crest of an anticline, the limestone and shale strata inclining in opposite directions. The district labors under the disadvantage that fuel is scarce, the nearest large supply being along the upper slopes of the Chisos mountains; but it is better situated with respect to water than the Terlingua district. The area of the field has not been outlined, but it is thought that important developments may be made in the near future.

2 THE ENGINEERING AND MINING JOURNAL, January 28, 1904.

A large amount of prospecting work was done during the year in the Terlingua district, which resulted in the extension of the known mineralized area. One of the most important results of this work was the discovery of a promising zone of mineralization 11 miles east of the Marfa and Mariposa orebodies. As described by Messrs. Kirk and Malcolmson,[3] the ore occurs in the form of numerous veinlets, which impregnate the country to such an extent that it can be profitably worked. The veinlets extend over an area of approximately 200 acres and run in all directions. The work done so far has demonstrated that the ore continues to a depth of 100 ft. The ore runs from 0.25 to 2 per cent quicksilver, and it has been demonstrated that several thousand tons can be mined, carrying an average of 0.6 per cent. The new district is called the Big Bend, after the immense turn to the north taken by the Rio Grande, 12 miles away. Water and fuel are more abundant than in the mines at Terlingua, but the district suffers from lack of transport facilities, as the nearest railroad point is Marfa, 104 miles distant. The cost of mining the ore already in sight should not exceed $3 per ton. The cost of treatment at Terlingua is $0.75 per ton, with the extraction of over 90 per cent of the mercury contained. A yield of 0.6 per cent of quicksilver, or 12 pounds per ton of ore, is worth $6.60, f. o. b. Marfa, so that the ore of this district can be treated at a profit. The erection of a Scott furnace has been undertaken by the Big Bend Cinnabar Mining Company, which has a fairly large tonnage of ore already developed. The Dallas Mining Company is also opening up some promising ground in the district.

QUICKSILVER PRODUCTION OF THE WORLD. (METRIC TONS.)

Year.	Austria.	Hungary.	Italy.	Japan.	Mexico.	Russia.	Spain.	United States.	Total.
1899	536	27	205	*Nil*	324	360	1,357	993	3,802
1900	510	32	260	3	124	304	1,095	983	3,311
1901	525	33	278	3	128	368	754	1,031	3,120
1902	525	2	259	(*a*)	191	416	1,425	1,208	4,026
1903	523	(*a*)	270	(*a*)	(*e*) 190	362	968	1,288	3,601

The figures for Austria, Italy and Spain for 1903 have been furnished by V. Spirek. (*a*) Not yet reported. (*e*) Estimated.

Australia.—The Great Australian Quicksilver Company, which owns the cinnabar mines at Yulgibar, on the Clarence river, New South Wales, has completed a 50-ton shaft furnace and begun active mining operations. So far, however, only experimental runs with the furnace have been made. In all 40 tons of ore were treated in 1903 for a yield of 1,000 lb. quicksilver. The Department of Mines of New South Wales has offered a reward of £500 to the person or company first producing 50,000 lb. of quicksilver from ores mined within the State.

Austria.—The production of quicksilver in 1903, as reported by the Minister of Agriculture, was 523 metric tons, against 525 tons in 1902. The important

3 *Op. cit.*, April 28, 1904.

quicksilver mines of Idria have been described by T. L. Genter.[4] The deposits are the second largest in the world, being next to those of Almaden in importance. Mining has been carried on for over 400 years. In 1580 the mines passed into the control of the Austrian crown, and they have since been operated as royal property. Idria is situated in southwestern Austria, on the southern slope of the Julian Alps, 1,000 ft. above the level of the sea. The geological formation consists of Paleozoic, Mesozoic and Cenozoic rocks, which are dislocated by a great fault, resulting in manifold depressions, overlaps and folds. The deposits are enclosed in Triassic strata and follow the general trend of the fault. The ore occurs for the most part as an impregnation, with a few well-defined veins. Cinnabar predominates, while native quicksilver and metacinnabar are found occasionally. The gangue is generally composed of quartz, calcite and dolomite.

LONDON QUICKSILVER STATISTICS. (*a*)

	1897.	1898.	1899.	1900.	1901.	1902.	1903.
	Flasks. (*b*)	Flasks. (*b*)	Flasks. (*b*)	Flasks. (*b*)	Flasks. (*b*)	Flasks. (*b*)	Flasks. (*b*)
Shipments from Spain to London	46,577	46,367	45,729	10,963	29,050	28,997	34,428
Shipments from Italy to London	4,450	5,650	6,206	6,045	5,254	3,187	
Total............	51,027	52,017	55,935	17,008	34,304	32,184	34,428
Shipments from London.............	31,734	31,026	31,903	24,958	*c* 26,830	20,000	18,599
Maximum price of Spanish.........	£7 7s. 6d.	£7 15s.	£9 12s. 6d.	£9 12s. 6d.	£9 2s. 6d.	£8 17s. 6d.	£8 15s.
Minimum price of Spanish.........	6 12s. 6d.	7 0s.	7 15s.	9 2s. 6d.	8 17s. 6d.	8 15s.	8 5s.

(*a*) From W. Sargant & Co.'s Annual Metal Circular, excepting for the years 1901, 1902 and 1903, which were taken from official reports. (*b*) American, Russian and Italian flask, 76.5 lb. (34.7 kg.); Mexican flask, 75 lb. (34.03 kg.); Spanish flask, 76 lb. (34.5 kg.). (*c*) For the year ending November 30, 1901.

The mines are opened by six shafts and have about 20 miles of workings. There are two drainage tunnels, of which the Antoni was begun in 1492, and is still in service. There are 12 levels, the deepest being 1,100 ft. About 1,200 persons are employed under ground and in the mills. The ore yields 0.6 per cent quicksilver, and, as 80,000 metric tons are mined annually, the output of metal is about 500 metric tons per year.

The process used in smelting the ore is simple. It is sorted, crushed and roasted in a muffle furnace especially constructed for the purpose. The quicksilver passes off with other gases and is condensed in large U-shaped earthenware receptacles, settling to the bottom as a slimy black mass or *stupp*. This *stupp* is run through the so-called press, a rotating machine, and the quicksilver is separated from the accompanying impurities. The *stupp* is then burned and the remaining quicksilver obtained. The latter is then packed for

4 The Engineering and Mining Journal, December 17, 1903.

shipment in heavy cast-iron receptacles, called *arrobas*, weighing about 34 kg. These flasks hold about 25 lb. of quicksilver.

According to the estimates of engineers, the deposits at Idria will continue to be productive for 40 or 50 years more at the present rate of working. A large portion of the quicksilver produced is converted into vermilion.

Italy.—The output of quicksilver in 1903, according to advices from Vincente Spirek, was 270 metric tons, a small increase over the production in the previous year. There are five mines in the country, situated near Monte Amiate, Tuscany. The record of all the mines from 1893 to 1902, inclusive, is as follows:

Year.	Ore Treated.	Average Yield.	Quantity of Quicksilver Produced.	Year.	Ore Treated.	Average Yield.	Quantity of Quicksilver Produced.
	Tons.	Per Cent.	Tons.		Tons.	Per Cent.	Tons.
1893....	14,950	1.9	273	1898....	19,201	0.80	193
1894....	15,022	1.7	258	1899....	29,332	0.70	205
1895....	10,504	1.9	199	1900....	33,930	0.75	260
1896....	13,701	1.8	188	1901....	35,878	0.72	278
1897....	20,659	0.99	192	1902....	44,261	0.58	259

Mexico.—The production of quicksilver in 1902 is reported officially as 191 metric tons, equivalent to 5,627 flasks. Six works were in operation for the treatment of quicksilver ores. The principal mines in this country are situated near Huitzecuco, State of Guerrero, where the ore occurs in limestones and slates and averages about 1.7 per cent quicksilver. The Cruz-Anexas plant alone turns out 250 to 300 flasks per month.

Peru.—The ancient mines of Huancavelica have been described by Augusto F. Umlauff.[5] The deposits are situated 458 km. by wagon road from Callao, at an elevation of 14,000 ft. above sea-level. They have been worked at different periods since their discovery, in 1566, and have produced a total of about 55,800 metric tons of quicksilver. The last period of successful operation was from 1846 to 1849, when the output averaged about one metric ton per week. The quicksilver is found in veins and stockworks, intersecting a series of sedimentary rocks, and as disseminated masses along the contact of igneous intrusions. Samples taken by the writer from the old workings showed an average of about 2 per cent quicksilver. Besides the ore still remaining in the mines, there are about 150,000 tons of waste and spent ore from former operations, which are estimated to contain 0.1 per cent quicksilver. There is abundant water power, as well as fuel, in the vicinity, and the mines seem to merit more detailed investigation with a view of their operation.

Russia.—The production of quicksilver is confined to a single concern, Messrs. A. Auerbach & Company, operating in the Ekaterinoslav district. The

5 *Boletin* del Cuerpo de Ingenieros de Minas del Peru, No. 7. Lima 1904.

output in 1903 was 362 metric tons, as compared with 416 tons in the previous year.

Spain.—The quicksilver mines of Almaden produced 18,255 metric tons of ore during 1903, which yielded 26,394 flasks of quicksilver. In addition to the above, a total of 12,115 tons of ore was mined in the provinces of Almeria, Granada and Oviedo, from which 1,675 flasks were obtained. There were 27 mines in operation during the year. At the Almaden mines four Cermak-Spirek furnaces are being installed. Two of the furnaces are designed to treat 12 tons of ore per day, and the third and fourth furnaces will have a capacity of 6 tons each per day.

SALT.

The total production of salt in the United States during 1903 amounted to 18,968,089 bbl., valued at $5,286,988, as compared with 23,849,231 bbl., valued at $5,668,636, in 1902. There was a marked decline in the output of Michigan and Kansas, which accounted for most of the falling off last year. Smaller decreases were recorded in New York, California, Utah and Texas, while the productions of Ohio and West Virginia showed slight gains.

PRODUCTION OF SALT IN THE UNITED STATES. (IN BARRELS OF 280 LB.)

Year.	California.	Illinois.	Kansas. (a)	Louisiana.	Michigan (c)	Nevada.	New York. (c)	Ohio, W. Virginia and Pa.	Utah.	Other States. (c)	Total Barrels.
1899...	590,386	54,500	2,172,000	357,143	6,699,060	5,900	7,726,172	1,215,000	448,132	594,555	19,861,948
1900...	455,271	55,000	2,350,000	386,744	6,845,685	5,786	8,123,550	1,688,286	267,857	560,550	20,738,729
1901 (b)	601,659	99,700	2,087,791	451,430	7,729,641	13,781	7,286,320	1,385,257	334,484	569,092	20,566,661
1902 (b)	682,660	90,009	2,158,486	399,163	8,131,781	14,829	8,523,389	2,318,579	417,501	1,112,824	23,849,221
1903 (b)	629,701	(d)	1,555,934	568,936	4,297,542	(d)	8,170,648	(d)	212,955	3,526,373	18,968,089

(a) Output in 1900 is estimated. (b) Statistics of the United States Geological Survey. (c) Includes salt used for the manufacture of alkali. (d) Included in 'Other States.'

The output of salt in the United States during 1903 was classified as follows (in barrels of 280 lb.): Table and dairy, 2,441,908; common fine, 6,351,855; common coarse, 1,829,460; packers, 270,170; solar, 1,743,101; rock, 3,175,521; milling, 37,657; other grades (including salt in brine used for the manufacture of sodium salts), 3,118,417; total, 18,968,089. As compared with the previous year the principal falling off was in the output of salt in brine which is used for the manufacture of sodium bicarbonate, soda ash, caustic soda and other sodium products.

Imports and Exports.—The imports of salt entered for consumption during 1903 were 331,961,807 lb., valued at $495,948, as compared with 369,528,186 lb., valued at $647,554, in the previous year. The imports in 1903 were classified as follows: In bags, barrels and other packages, 72,838,011 lb. ($259,029); in bulk, 151,635,246 lb. ($134,714); salt for curing fish, 107,-487,450 lb. ($102,205). The exports of salt of domestic manufacture in 1903 amounted to 25,499,630 lb., valued at $95,570, against 10,188,771 lb., valued at $55,432, in the preceding year. According to the tariff law of 1897 a duty of 12c. per 100 lb. is levied upon imports of salt in bags, barrels or other packages, and 8c. per 100 lb. upon salt in bulk.

SALT PRODUCTION OF THE CHIEF COUNTRIES OF THE WORLD. (IN METRIC TON. AND DOLLARS.)

Year	Algeria.		Austria. (a)		Canada.		France.		Germany.	
1898.	21,300	$86,000	341,959	$10,607,799	51,796	$234,520	999,283	$2,115,120	1,370,341	$3,954,745
1899.	17,378	67,300	342,059	10,124,760	51,796	234,520	1,193,532	2,506,832	1,432,181	3,978,753
1900.	18,325	76,288	330,277	9,957,173	56,296	279,458	1,088,634	2,415,973	1,514,027	4,627,500
1901.	18,518	79,976	333,238	9,888,231	53,927	262,328	910,000	2,012,800	1,563,811	5,064,750
1902.	27,263	112,792	310,807	9,330,813	57,203	296,845	863,927	2,493,011	1,583,458	4,830,070

Year.	Greece.		Hungary. (a)		India. (d)		Italy.	
1898	25,250	$363,600	178,551	$5,679,534	1,043,828	$1,485,702	481,171	$831,216
1899	37,125	579,150	182,593	5,479,782	977,240	1,324,748	392,668	638,492
1900	22,411	336,165	189,363	5,456,600	1,021,426	1,146,363	367,255	602,440
1901	23,079	351,700	211,321	6,553,449	1,120,187	1,405,682	435,187	668,982
1902	25,200	362,750	211,679	6,600,748	1,057,135	1,199,779	458,497	686,525

Year	Japan.		Russia.		Spain.		United Kingdom.		United States.	
1898	646,719	(b)	1,505,600	2,566,906	479,358	1,025,682	1,908,723	3,100,575	2,382,197	4,753,664
1899	390.433	(b)	1,681,362	2,767,168	598,108	1,091,133	1,945,531	3,220,870	2,522,610	5,437,941
1900	669,694	(b)	1,968,005	3,124,000	450,041	834,535	1,873,601	3,059,600	2,651,278	6,944,603
1901	659,118	4,808,185	(c)	(c)	345,063	599,934	1,812,180	2,864,950	2,612,204	6,617,449
1902	690,896	4,459,245	(c)	(c)	426,434	682,664	1,924,273	2,886,665	2,409,174	5,286,988

(a) The high valuation in Austria and Hungary is due to government monopoly and high taxation. (b) Not reported in official statistics. (c) Statistics not yet published. (d) Does not include salt made in certain native states and untaxed. In addition Australasia produced in 1902, 42,166 metric tons ($259,375); Ceylon, 1902, 2,794 metric tons; Cyprus, 1902, 3,440 metric tons ($23,315); Dutch West Indies, 1902, 1,100 metric tons ($9,740); Peru, 1901, 15,849 metric tons ($392,380); Roumania, 1901, 90,000 metric tons (monopoly); Switzerland, 1902, 50,990 metric tons; Tunis, 1902, 21,600 metric tons ($14,000); Turks and Caicos Islands, 51,011 metric tons ($110,980).

SULPHUR AND PYRITE.

BY CHARLES C. SCHNATTERBECK.

In 1903 the United States produced 39,310 short tons of sulphur, valued at $789,738, which is a record production and compares with 8,336 tons, valued at $169,746 in 1902. As in previous years Louisiana reported the largest quantity, and was followed by Nevada and Utah.

The consumption of sulphur in the manufacture of sulphuric acid and for other purposes amounted to 569,607 short tons in 1903, as against 547,770 tons in 1902. Of the 1903 supply, 322,499 short tons, or 56.6 per cent was obtained from domestic, Spanish and Canadian pyrite, the balance of 247,108 tons, or 43.4 per cent being recovered largely from Sicilian and Japanese brimstone. In addition an increased quantity of sulphur for making acid has been recovered from the fumes in roasting blende, chiefly at La Salle and Peru, Ill., and Argentine, Kansas. At Niagara Falls, N. Y., sulphuric acid is being produced from the electrolytic treatment of galena, and in California, the Mountain Copper Co., at Keswick, has decided to make acid from its low-grade copper ores.

CONSUMPTION OF SULPHUR IN THE UNITED STATES. (IN LONG TONS.)

Source.	1900.	1901.	1902.	1903.
Sulphur—Domestic production	4,630	6,866	7,443	35,098
Imports	166,457	175,310	176,951	191,005
Total	171,087	182,176	184,394	226,103
Exports	540	207	1,253	967
Consumption	170,547	181,969	183,141	225,136
(*a*) Sulphur contents at 98 per cent	167,136	178,330	179,478	220,633
Pyrite—Domestic production	201,317	234,825	228,198	199,387
Imports	329,449	403,706	440,363	427,319
Total	530,766	638,531	668,561	626,706
Exports	......	......	3,060	1,330
Consumption	530,766	638,531	665,501	625,376
Sulphur in domestic at 44 per cent	88,579	103,323	104,071	87,730
Sulphur in foreign at 47 per cent	154,841	189,742	205,532	200,215
Total sulphur content	243,420	189,742	309,603	287,945
Grand total sulphur consumption	410,556	471,395	489,081	508,578

(*a*) Includes crude and refined sulphur.

Alaska.—A large deposit of sulphur on Mount Makuskin, Unalaska island, is to be worked by the Philadelphia Crude Ore Co. It is proposed to construct a tramway from the mine to tidewater in Captain's Bay, a distance of about twenty-five miles.

Louisiana.—The production of sulphur by the Frasch process which consists in melting the sulphur in place with hot water and then pumping to the surface, has increased largely during the past year. The sulphur analyzes as high as 99.9 per cent. in purity. Until quite recently the entire production was marketed in the West, owing to the high rail freight to eastern consuming points. In 1904, however, the Union Sulphur Co. succeded in placing a cargo of 3,000 tons in New York at a favorable freight rate, and during the year will establish a sales-agency here. The company is operating two wells at present, which pump between 500 and 700 tons of sulphur a day, and has a large stock on hand, ready for shipment. An order was booked for 2,000 tons for Sweden, but it does not seem likely that the foreign trade will be developed so long as the domestic market can take care of the output.

Nevada.—The only sulphur produced has come from the Rabbit Hole district, where the Nevada Sulphur Mine Company is actively at work. The refined sulphur marketed by the company is crushed to pea size, ground with buhrstones and packed in 110 lb. sacks. The consumers are situated in San Francisco and other Pacific Coast cities. Development work is to be begun on the property of the Humboldt Sulphur Co., about two miles from Humboldt station on the Southern Pacific Railway. Refining works are being built, and it is said that there are fully 20,000 tons sulphur, analyzing 30 to 40 per cent. available for treatment.

Utah.—Production has increased to 2,000 tons in 1903, and has been reported from Beaver County, where the Utah Sulphur Co. is working.

Foreign Countries.

Chile.—Favored by an active mining industry, particularly nitrate of soda, the demand for sulphur to make blasting powder, has grown rapidly in recent years. The sulphur mines near Arica and at Taltal continue to supply the demand. Some mining has also been done in the neighborhood of the extinct volcanoes of Tacora and Chupiquina.

Italy.—Fully 85 per cent. of the production of sulphur in this country is pledged by a long-time agreement with the Anglo-Sicilian Sulphur Co., which expires in 1906. With the exception of 275,000 or 375,000 tons, usually carried in stock at the mines and seaports in Sicily, the bulk of the production of brimstone is exported, principally to the United States, the world's largest consumer. The production in 1903 (536,044 tons) was larger than the previous year, although labor troubles, initiated by the increase in accident insurance rates, threatened to stop work at the mines indefinitely. The insurance is compulsory by law and the mine owners were determined to deduct the premium from laborers' wages, thus compelling the Anglo-Sicilian Sulphur Co. to pay 6d per ton more for brimstone. To attain their end mine-owners requested the Government to impose an additional export tax of 1.50 lira per ton, which would have increased the value of brimstone 1s (24c.) per ton.

Fearing prolonged trouble, the sulphur trust has guaranteed to assume to its charge the miners' insurance premium.

Another feature of the Sicilian industry is the progressive spirit shown to improve the quality and increase the yield of the brimstone marketed. By

TOTAL EXPORTS OF SULPHUR FROM SICILY, 1895-1903. (IN LONG TONS.) (*a*)

Country.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.
Austria	12,170	13,799	15,993	15,796	18,519	21,594	18,842	19,086	17,926
Belgium	6,410	7,527	9,253	8,402	7,481	9,721	7,471	12,323	15,233
France	69,696	76,739	84,895	88,657	96,043	103,647	74,394	67,249	74,372
Germany	15,472	15,680	19,721	27,048	25,933	28,702	23,448	25,906	32,553
Greece and Turkey	16,195	18,556	13,866	24,808	18,656	19,647	21,702	20,548	22,133
Holland	3,335	3,834	3,599	5,646	6,408	18,595	10,848	8,648	5,157
Italy	49,349	54,009	73,052	62,652	87,230	101,073	74,516	45,603	45,572
Portugal	14,562	12,001	7,054	8,257	12,269	10,937	11,335	10,614	14,064
Spain	5,753	5,910	4,039	3,233	7,757	6,187	2,979	2,249	4,099
Sweden and Norway	*b*5,730	*b*14,540	*b*11,226	*b*12,331	*b*12,476	*b*22,681	*b*24,486	*b*24,918	*b*28,292
Russia	17,962	18,752	17,532	12,285	19,211	22,090	15,110	17,295	15,068
United Kingdom	24,043	21,913	24,520	26,983	25,038	23,973	22,468	25,477	19,210
United States	99,227	124,923	118,137	138,435	128,441	162,505	144,817	168,919	155,996
Other countries	7,732	8,562	7,651	12,791	13,569	6,810	9,887	18,484	*c*25,833
Totals	347,636	396,745	410,538	447,324	479,031	558,162	462,299	467,319	475,508
Stock in Sicily end year	203,756	222,999	240,367	248,023	277,098	221,204	302,410	339,113	361,220

(*a*) From 1895-1901 by A. S. Malcomson, New York; for 1902 and 1903, by Emil Fog & Sons, Messina. (*b*) Includes exports to Denmark. (*c*) Australia, 4,756 tons; Brazil, 414; Canada, 808; East Indies, 3,182; North Africa, 3,928; South Africa, 5,465; South America, 1,943; Asia, Bulgaria, Egypt, Malta, Roumania, Switzerland and Syria, together, 5,337; total, 25 833 tons, as against 18,484 tons in 1902.

changing the method of fusing the crude ore, a smaller quantity of best thirds is being produced, while a finer grade of best unmixed seconds is obtained. It is interesting to mention here that the difference in value between best seconds and best thirds, formerly about 8s per ton, is now only 2s, as a result of the reduced output and improved quality of the latter. The demand for thirds is principally from the refineries, its use for making sulphuric acid

SHIPMENTS OF SULPHUR FROM SICILY TO THE UNITED STATES. (IN LONG TONS.)

Port.	1898.		1899.		1900.		1901.		1902.		1903.	
	Seconds.	Thirds.	Seconds.	Thirds.	Seconds.	Thirds.	Seconds.	Thirds.	Seconds.	Thirds.	Seconds.	Thirds.
New York	49,614	22,475	56,746	26,650	70,446	24,307	72,104	19,631	76,383	26,842	70,800	21,201
Charleston	500	1,600	......	......	......	......	......	......	......	......	......	......
Philadelphia	1,200	5,400	2,740	8,000	1,600	5,100	2,300	9,595	3,500	10,399	4,910	8,500
Baltimore	2,350	12,015	3,800	8,600	6,800	5,400	7,550	2,900	9,065	2,400	10,900	2,000
Boston	4,500	1,550	600	1,000	1,500	2,500	3,497	3,200	2,204	2,300	5,508	2,450
Savannah	1,980	......	......	......	1,750	......	......	......	......	......	......	......
Wilington, N.C.	500	1,200	......	......	......	......	......	......	......	......	......	......
New Orleans	500	2,000	......	800	......	3,000	......	1,400	......	1,000	......	......
Portland, Me.	13,750	......	18,915	......	27,612	......	21,990	......	26,328	......	23,855	......
Other ports (*a*)	14,101	3,200	590	......	12,490	......	650	......	8,498	......	5,872	......
Totals	88,995	49,440	83,391	45,050	122,198	40,307	108,091	36,726	125,978	42,941	121,845	34,151

(*a*) Norfolk, Mobile, San Francisco, Bangor, Portland, Ore., and Canada.

now being met largely by the cheaper pyrite sulphur, excepting when an acid free from arsenic is desired. Best unmixed seconds finds its largest consumption as an insecticide for vineyards, and in paper making. Of late there has sprung up a good demand for ground best unmixed seconds which is sold at 5s 6d to 5s 9d per ton above the crude product.

Following are the average selling prices per long ton, f. o. b. shipping ports in Sicily, in 1903:

Quality of Sulphur.	High.	Low.	Average for Year.
	s. d.	s. d.	s. d.
Best unmixed seconds, bulk	83 9	80 9	82 6
Best unmixed seconds, ground, bags	89 6	87 6	88 3
Best unmixed thirds, bulk	79 9	78 0	79 2
Current thirds, bulk	79 0	76 9	77 9
Refined block, bulk	88 6	85 9	87 5
Refined roll, bags	94 9	92 9	93 10
Refined roll, casks	100 0	96 9	98 6
Refined roll, usual size sticks, cases	103 9	101 9	102 11
Refined roll, small sticks, cases	106 6	103 9	104 9
Sublimed flowers, pure, bags	108 6	103 6	106 2
Sublimed flowers, current, bags	99 9	97 0	98 3
Sublimed flowers, commercial, bags	94 9	92 3	93 5

Compared with 1902, these prices show a substantial increase, excepting for crude seconds, which are fractionally less, owing partly to the introduction in the market of ground seconds, and also to the improved quality of best thirds.

The Anglo-Sicilian Sulphur Co. reports for the year ending July 31, 1903—the seventh of its existence—a net profit of £120,513. From this dividends of 6 per cent., amounting to £41,994 and a bonus of £1,944, free of income tax, have been paid on the 700,000 preference shares, and 50 per cent., or £17,500 on the 700,000 ordinary shares. There has been credited to capital guarantee fund, £15,704; reserve against eventual depreciation of stocks of sulphur, £39,371; for depreciation in the guarantee and reserve fund investments, £4,617, and income tax, £4,000. The general reserve fund stands at £123,902, making with the capital guarantee fund as above, a reserve of £206,264, besides the £96,401 held for any depreciation of stocks of sulphur.

Japan.—The output of sulphur in 1903 was larger than 1902, when 12,547 tons were reported, but in 1904, the quantity will likely be less. In 1903 the total exports from Hakodate were 19,047 tons, of which 15,987 tons went to the United States, principally to San Francisco, Cal., where it is used in the manufacture of gunpowder.

Mexico.—Several discoveries of what are believed to be good deposits of sulphur have been reported in 1903, but their development will depend entirely upon adequate transportation facilities. The Sulphur Mining & Railway Company with property some 60 miles from San Luis Potosi, has acquired a concession for building a railroad to connect with the Tampico branch of the Mexican Central, at Cerritos. Near Ensenada, Lower California, J. A. Dubbs has begun shipping from his mine to San Francisco. In Durango, hope is centered in the discovery made at Jaboncillo, but as yet no work has been done on the deposit. There has been much speculation about the Popocatepetl volcanic deposit, acquired by Americans who intend to mine the sulphur and incidentally operate a tourist's scenic railway. The Popocatepetl Co., of New York, capitalized at $5,000,000, according to the proposed plan, will convey the sulphur-coated rock by an aerial tram from the bottom of the crater and over its rim to the modern refining furnaces, to be situated on the timber line, about 1,000 ft. from the base. When refined the sulphur will be carried by cable to the Inter-Oceanic Railway station at Cedar for shipment to Vera Cruz, then by water to the distributing markets. In the refineries steam will be used to separate the sulphur from the rock and dirt, and it is claimed that the crude mineral will average 40 per cent in sulphur content, or, say, 500 short tons crude ore will yield 200 long tons best unmixed seconds, analyzing over 98 per cent in purity. In contradistinction to the report of the commission appointed by the Mexican Secretary of War in 1894 to examine Popocatepetl, Frederick J. M. Rhodes[1] says investigation has shown that at the bottom of the crater there is a lake, the depth of which could not be determined, which is almost round with a diameter of about 100 feet. On opposite sides of the lake there are two vents emitting steam, containing sulphurous fumes. On these fumes striking the cold air they crystallize and form a deposit of sulphur on the surrounding rocks. The extent of this deposit is about 120 lb. in 30 days. There is no other evidence of sulphur deposits either near, or about, the crater, or on the outside of it. About 4,500 ft. from the top of the volcano, there are eight native crucibles connected by piping to a large rock chimney, some 30 ft. in height. These have been used for refining sulphur taken from the crater, but there is no evidence of any great amount having been refined.

Analysis of crude sulphur from Mexico by Frank B. Carpenter show that only a part of the sulphur is soluble in carbon bisulphide and the ignition method cannot be used on account of the presence of calcium sulphate containing water of crystallization. As this water is gradually given off at 100° C., the moisture is determined by drying in a vacuum over sulphuric acid. The substance is then boiled with dilute hydrochloric acid, filtered in a Gooch crucible, dried and weighed. This removes the calcium sulphate; the sulphur in the residue is found to be readily soluble in carbon bisulphide.

Peru.—The Sechura sulphur beds are to be developed by a £125,000 corporation, composed of Peruvians and Britishers.

Russia.—The mines in Daghestan, Poland and Turkestan continued to produce in 1903, although some uneasiness among the miners has been felt from the war with Japan.

Venezuela.—Development work has been fairly active at the mine near Carupano, and a small shipment of sulphur was made to the United States in 1903.

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[1] ENGINEERING AND MINING JOURNAL, May 5, 1904.

WORLD'S PRODUCTION OF SULPHUR. (IN METRIC TONS.) (*a*)

Year	Austria (*d*)	France (*c*)	Hungary	Germany	Greece	Italy (*b*)	Japan	Russia	Spain	Sweden	United States
1897	530	10,723	112	2,317	358	496,658	12,013	574	*b* 3,500	*Nil.*	1,717
1898	496	9,818	93	1,954	135	502,351	10,339	1,018	3,100	50	2,770
1899	555	11,744	116	1,663	1,150	563,697	10,241	451	1,100	*Nil.*	1,590
1900	862	11,551	123	1,445	891	544,119	14,435	1,586	750	70	4,630
1901	4,911	6,836	137	963	2,336	563,096	16,578	(*e*)	610	*Nil.*	6,977
1902	3,721	8,021	105	487	1,391.	510,332	12,547	(*e*)	450	74	7,565

(*a*) From the official reports of the respective governments. The sulphur recovered as a by-product by the Chance-Claus process in the United Kingdom, amounting to between 20,000 and 30,000 long tons annually, is not included. (*b*) Crude. (*c*) Raw mineral; limestone impregnated with sulphur. (*d*) Crude rock. (*e*) Statistics not yet published.

Pyrite.

The retrenchment in the fertilizer acid industry in 1903, following the unprecedented activity of 1902, has been largely responsible for the smaller production of pyrite. In 1903 the United States mined 199,387 long tons pyrite, containing approximately 86,667 tons sulphur, valued at $787,579. In 1902, the output was 228,198 tons—the second best record—which contained 100,407 tons sulphur, valued at $971,796. No new mines were opened in 1903, and the competition with importers who are frequently favored by the railroads leading to inland-consuming markets, has prompted some producers to curtail mining. Foreign pyrite is imported free of duty, pays an ocean freight from Huelva, Spain to Atlantic ports of 9s 6d @ 12s 6d ($2.28 @ $3) per ton, and has met a good demand for non-arsenical ore. The bulk of the American imports, however, are of pyrite carrying when burned more or less arsenic, from 1.5 to 2 per cent. copper, about 40 per cent. iron, and a small amount of gold, the latter valued at 50c. to $1 per ton, which is seldom recovered. Besides the Spanish imports, an increased quantity of iron and copper pyrite has come from Newfoundland, where Americans are working mines. The total net imports of all classes of pyrite into the United States in 1903 were 425,989 long tons, containing 200,215 tons sulphur, valued by the importers' invoices at $1,628,600. Compared with the previous year there is a decrease of 14,374 tons in the quantity of pyrite imported, and a falling off of $22,252 in value in 1903. It is noteworthy that pyrite, both imported and domestic, furnished 56.6 per cent. of the demand for sulphur in this country in 1903. In 1902 the ratio was 62.4 per cent., while in 1896, when the Sicilian sulphur combination was organized, the proportion was only 49.4 per cent. In other words the consumption of pyrite sulphur has increased over 100 per cent. in seven years, a fact that may be further emphasized by the statement that the increase in brimstone is only about 57 per cent. This may be explained by the considerably lower cost of pyrite sulphur, and its adaptability to industrial purposes heretofore largely satisfied by crude brimstone.

PRODUCTION, IMPORTS AND CONSUMPTION OF PYRITE IN THE UNITED STATES.
(IN TONS OF 2,240 LB.) (*a*)

Year.	Production.		Imports. (*b*)			Consumption.	
1895	107,371	$342,587	190,436	46%	$673,812	297,787	$1,016,669
1896	109,282	292,626	199,678	47%	1,140,571	308,960	1,433,197
1897	133,368	404,699	259,546	47%	847.419	392,914	1,252,118
1898	191,160	589,329	252,773	47%	717,813	443,933	1,307,142
1899	178,408	583,323	269,868	47%	1,077,061	448,276	1,660,384
1900	201,317	684,478	322,484	47%	1,055,121	523,801	1,739,599
1901	234,825	1,024,449	403,706	47%	1,415,149	638,531	2,439,598
1902	228,198	971,796	440,363	47%	1,650,852	668,561	2,622,648
1903	199,387	787,579	425,989	47%	1,628,600	625,376	2,416,179

(*a*) These statistics do not include the auriferous pyrite used for the manufacture of sulphuric acid in Colorado. (*b*) Net imports, less re-exports of 3,060 tons, in 1902, and 1,330 tons, in 1903.

From all indications the consumption of pyrite sulphur will exceed that of brimstone for years to come, and it is not unlikely that the zinkiferous sulphide ores in Arkansas, Missouri, Kentucky, Kansas, Colorado and other western States will be profitably utilized for the manufacture of sulphuric acid. At Peru and La Salle, Ill., and Argentine, Kas., large quantities of acid are made from roasting zinc blende. Experiments are also being made to recover sulphur for making acid from Southern pyrrhotite ores, and when once the industry has been established by the General Chemical Co. there is promise of most aggressive competition in the trade. An advantage expected is that the iron recovered from the cinder from burning these pyrrhotite ores can be manufactured into pig iron or steel, thus greatly reducing the first cost of producing the sulphuric acid.

A new and promising field for the consumption of pyrite is in the manufacture of sulphur dioxide gas for bleaching wood pulp used in making paper by the sulphite process. Until quite recently brimstone was used entirely for this purpose, but experiments with pyrite both here and abroad have proved successful, particularly in Norway. It is stated that the economy to be realized by three paper mills in Norway by using 10,000 tons pyrite annually instead of brimstone, is 5 kr., or about $1.50 per ton.

The value of domestic pyrite, containing from 42 @ 44 per cent. sulphur, ranged from 9 @ 11c. per unit, or say, from $3.87 @ $4.84 per long ton, f. o. b. Atlantic coast mines. Foreign pyrite, analyzing from 46 to 52 per cent sulphur, sold at Atlantic ports at 9 @ 11.5c. per unit ($4.23 @ $5.41 per ton) for fines and 10 @ 13.5c. per unit ($4.70 @ $6.35 per ton) for lump ore. Taking the average price of both domestic and imported pyrite in 1903 at $4.76 per ton, and calculating 2.2 tons to be equal to a ton of crude sulphur, consumers have paid about 50 per cent less than was charged for brimstone. Of course, the pyrite had to be burned at some expense, but when the profit from selling the metallic cinder is deducted there is still an advantage over brimstone.

Alabama.—The Clay county iron pyrite deposits will be opened by a new fertilizer manufacturer, the Alabama Phosphate Co. with a capital of $450,000.

The completion of the Eastern Railroad from Talladega to Pyriton will greatly facilitate the development of the new deposits in this locality. This source of supply is expected to be beneficial to the fertilizer manufacturers at Nashville, Tenn., who are now using quantities of Tennessee phosphate rock and need the sulphur for acid.

California.—The extension of the sulphuric acid industry, encouraged by the prosperity of the powder factories, has resulted in two producers of pyrite to increase their output in 1903. Besides this there has been consumed an appreciable quantity of gold and silver arsenical concentrates for the manufacture of acid by the Peyton Chemical Company.

Colorado.—There was no production of pyrite in 1903, but the Western Chemical Co., of Denver, used 7,851 tons for making acid.

Massachusetts.—The Davis Sulphur Ore Co., with a mine at Charlemont, Franklin county, is the only producer in the State.

New York.—Work has not yet been resumed at the Stella mine at De Kalb Junction, and the High Falls Pyrites Co., in St. Lawrence county, continues to be the only producer.

Ohio.—Pyrite in the form of "coal brasses" is recovered to some extent in coal washing operations. In 1903 there were two producers, reporting 4,632 tons. The output is necessarily limited by the small demand for acid made from pyrite since brimstone from Louisiana can be imported at comparatively little cost.

Virginia.—Four producers reported nearly 30 per cent of the total output in the United States. Louisa county continues to be the principal source of supply, although an appreciable quantity has also come from other localities. The bulk of the output has been consumed by the Southern fertilizer combination known as the Virginia-Carolina Chemical Company.

WORLD'S PRODUCTION OF PYRITE. (IN METRIC TONS.) (*a*)

Year.	Belgium.	Bosnia.	Canada.	France.	Germany.	Hungary.	Italy.	Newfoundland.
1898	147	240	29,228	310,972	136,849	58,079	67,191	33,100
1899	283	430	25,117	318,832	144,623	79,519	76,538	31,500
1900	400	1,700	36,316	305,073	169,447	87,000	71,646	*Nil.*
1901	560	4,570	31,987	307,447	157,433	93,907	89,376	7,653
1902	710	5,170	32,310	318,235	165,225	106,490	93,177	26,417

Year.	Norway.	Portugal.	Russia.	Spain.	Sweden.	United Kingdom.	United States.	Totals.
1898	89,763	248,218	24,570	260,016	386	12,302	194,219	1,465,086
1899	95,636	275,658	23,251	319,285	150	12,426	181,263	1,584,511
1900	98,945	345,330	23,154	356,018	179	12,484	204,538	1,743,011
1901	101,894	443,182	(*b*)23,000	399,601	*Nil.*	10,405	238,661	1,909,766
1902	(*b*)100,000	413,309	(*c*)25,000	477,376	*Nil.*	9,315	231,849	2,004,583

(*a*) From the official reports of the respective governments. (*b*) Estimated. (*c*) Does not include the production of copper-iron pyrite, from which the copper is extracted in Spain.

Foreign Countries.—With the exception of Spain and Canada there seems to be little inclination on the part of foreign countries to encourage the mining of pyrite. One reason for this is that they are well supplied with brimstone by Sicily, and as in the case of Germany, make sulphuric acid largely from the fumes obtained in copper smelting. In Canada—a country that uses annually over 5,000,000 lb. sulphuric acid—sulphur for making acid and for manufacturing paper by the sulphite process, is recovered from smelting Sudbury nickel ores. The production of pyrite in Canada, chiefly in Newfoundland where Americans are working, amounted in 1903 to 33,530 tons, valued at $126,133. Of this quantity there was exported to America 21,067 tons, valued at $59,604. The largest producer in Spain is the Rio Tinto Co., which reported 667,748 long tons pyrite, and 118,171 tons sulphur ore, both showing a substantial increase over 1902. In 1903 the Rio Tinto Co. shipped 163,245 tons pyrite to the United States. Portugal, where the Mason & Barry, Ltd., is the most prominent operator, the output of copper-iron pyrite, carrying from 0.6 to 2.5 per cent copper and sold for its sulphur content, promises to grow. In 1902 the Mason & Barry, Ltd., reported shipments of 413,309 tons of sulphur ore, but since then has spent more money in development work and has purchased suitable machinery for handling its product. It is interesting to mention here that Great Britain, the largest purchaser of foreign pyrite, and itself one of the smallest producers, imported in 1903 a total of 735,939 tons. These imports, showing a large increase over 1902, contained approximately 345,891 tons of sulphur, which compares with the imports of 20,168 tons brimstone from Sicily. The sulphur recovered from pyrite is used by Great Britain in the manufacture of sulphuric acid, while the brimstone is principally refined by the Chance-Claus process, and marketed as such.

TALC AND SOAPSTONE.

The production of talc and soapstone in the United States in 1903 amounted to 58,901 short tons, valued at $644,060, as compared with 97,954 short tons, valued at $1,140,507, in the previous year. The falling off was due almost entirely to the decreased output of fibrous talc, which amounted only to 32,230 tons, valued at $225,600, against 71,100 tons, valued at $615,350, in 1902. Of common talc and soapstone the production in 1903 was 26,671 tons, valued at $418,460, against 26,854 tons, valued at $525,157, in 1902.

Year.	Production.				Imports.	
	Fibrous Talc.		Common Talc and Soapstone.			
	Short Tons.	Value.	Short Tons.	Value.	Short Tons.	Value.
1898	54,807	$285,709	27,974	$237,280	445	$5,526
1899	57,120	272,595	26,682	241,267	254	3,534
1900	45,000	236,250	26,726	374,164	79	1,070
1901	69,200	483,600	28,643	424,888	2,386	27,015
1902 (a)	71,100	615,350	26,854	525,157	2,859	35,366
1903 (a)	32,230	225,600	26,671	418,460	1,791	19,677

(a) Statistics of the United States Geological Survey.

The talc mines in St. Lawrence county, New York, were worked on a diminished scale in 1903, owing principally to the falling off in demand, due to the labor troubles in the paper manufacturing industry. These mines supply the entire output of fibrous talc in the United States. New deposits of common talc have been opened in Windsor county, Vt., and in Georgia. It is believed that the import duty of 1c. per lb. which was placed on ground talc, will serve to stimulate the production of the southern States, where most of the supply of common talc is obtained.

TIN.

BY D. H. NEWLAND.

As in previous years there was no commercial production of tin in the United States during 1903. A few shipments of ore were made from Alaska, and one small lot was shipped from Gaffney, South Carolina, to England, but there is no immediate prospect of any large supplies being derived from these sources. The Alaskan fields attracted a good deal of attention during the year; a number of new occurrences were found and the limits of the tin-bearing area have been considerably extended. One of the most notable discoveries was made in the Lost River district, near Cape Prince of Wales, where the existence of lode tin has been definitely established. The value of the deposit cannot be estimated as yet. Very little has been done in the way of developing the deposits of stream tin in the Seward Peninsula, and it is still a question whether they can be profitably worked. This part of Alaska presents great natural difficulties to mining operations, as it is devoid of timber and inaccessible to means of transport for more than half the year.

A smelting works for the treatment of tin ores was erected during 1903 at Bayonne, N. J., by the International Tin Company. The plant was designed to treat about 50 tons per day, but was not put in operation owing to the fact that a prohibitory tax was placed on the exports of tin ore from the Malay Peninsula whence it was expected to draw the supplies.

THE PRINCIPAL TIN SUPPLIES OF THE WORLD. (*a*) (IN LONG TONS.)

	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.
English production	4,837	4,453	4,684	4,013	4,268	4,566	4,392	4,300
Straits shipments to Europe and America	47,180	41,700	43,350	44,460	46,070	50,339	51,831	52,215
Australian shipments to Europe and America	4,320	3,466	2,420	3,337	3,178	3,276	3,206	4 157
Banka sales in Holland	6,735	8,900	9,038	9,066	11,820	14,978	14,978	15,070
Sales of Singkep in Holland	839	800	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*	*Nil.*
Billiton sales in Java and Holland	5,040	5,100	5,342	5,057	5,820	4,387	3,897	3,650
Bolivian arrivals on Continent	210	1,208	1,000	813	1,900	9,670	10,150	9,790
Bolivian arrivals in England	3,829	4,298	3,464	3,940	5,037			
Straits shipments to India and China.	6,118	3,214	2,551	1,484	1,785	2,650	1,925	3,150
Totals in long tons	79,108	73,139	71,763	72,557	79,878	89,860	90,269	92,332
Totals in metric tons	80,374	74,309	72,911	73,718	81,156	90,279	91,715	93,799

(*a*) This table is based on the statistics compiled by Wm. Sargant & Co., and by Ricard & Freiwald, but the figures of English production are taken from the British Blue Book. This table does not include the production of Germany, Austria, Spain, Portugal and other countries.

IMPORTS OF TIN INTO THE UNITED STATES.

Year.	Pounds.	Value.	Year.	Pounds.	Value.	Year.	Pounds.	Value.
1898..	62,748,399	$8,770,221	1900..	69,989,502	$19,458,586	1902..	85,043,353	$21,263,337
1899..	71,248,407	16,748,107	1901..	74,560,487	19,024,761	1903..	83,133,847	22,265,367

Tin Mining During 1903.

Alaska.—The discovery of lode tin in the Lost River district, about 30 miles east of Cape Prince of Wales, was reported during 1903. The tin occurs in a dike of granite intersecting limestone. Prospecting was carried on actively at this locality, and it is believed that productive mines may be developed. The work of the U. S. Geological Survey in the Seward Peninsula indicates that the distribution of tin is wider than at first supposed.

According to Arthur J. Collier[1] cassiterite, or black tin, is found at irregular intervals over an area of 450 square miles, which embraces the western end of the Seward Peninsula. Buck creek is the center of placer mining, and the gravels have been found to carry values from the mouth of the creek to within a mile of its source. The pay-streak is limited to the stream bed and flood deposits, the ore being found from the surface down to red-rock, which is a dark slaty schist. Several tons of ore were shipped from Buck creek in 1902, and a number of companies started operations during 1903. Pannings indicate that the gravels carry about 27 lbs. of concentrates to the cubic yard, the concentrates running 60 per cent.

The lode tin deposits of the Lost River district occur four or five miles from the coast. The river has a length of about 10 miles, draining the central part of the York Mountains and entering Bering sea 10 miles west of Port Clarence. Tin has been found on two tributaries of Lost River, known as Tin creek and Cassiterite creek, which enter some three or four miles from its mouth. The country is composed chiefly of Silurian limestones which are intersected by dikes of igneous rocks. Between Tin creek and Lost River there is a boss of granite which outcrops in a nearly circular area of half a mile in diameter. Around the margins of this area the limestone is considerably altered and contains small dikes of pegmatitic rock, presumably offshoots from the granite. A wide porphyry dike which cuts the limestones four or five miles from the coast, and which has been traced from Tin creek on the east to Cassiterite creek on the west, for a distance of a mile, carries most of the tin that has thus far been found. The tin occurs on the croppings of the dike and strewn over the surface along its course. Some of the weathered ore obtained from the dike has the appearance of vein quartz with small crystals of cassiterite distributed through it, while other specimens show their granitic origin and contain little quartz. The cassiterite crystals vary from the

1 'Tin Deposits of the York Region, Alaska.' *Bulletin* 225 of the U. S. Geological Survey, Washington, 1904.

sizes of a pin-head to a walnut, but the ore also is found in irregular masses, as well as in veins. Tourmaline, pyrite, galena and garnet occur as accessory minerals. The dike has been prospected by cross-cut trenches, but the excavations have not gone far enough to permit of systematic sampling.

Discoveries of lode tin have been reported by prospectors from other localities, notably at Brooks Mountain, near the head of Lost River, four miles north of the Lost River tin deposits; on the hills east of Don River; at Ears Mountain, about 50 miles north of Port Clarence; at Hot Springs, about 70 miles northwest of Port Clarence; about 20 miles south of Kotzebue Sound; and on the Diomede Islands in Bering Strait, 30 miles west of Cape Prince of Wales. So far, however, the presence of workable deposits has not been confirmed.

PRODUCTION OF TIN IN THE WORLD.

Year.	Australia. (*a*)			Austria. (*b*)			Banka and Billiton. (*c*)	Bolivia. (*d*)	England. (*b*)		
	Net. Tons	Value.	Per M. Ton.	Met. Tons.	Value.	Per M. Ton.	Metric Tons.	Metric Tons.	Metric Tons.	Value.	PerM Ton.
1898 .	908	$302,825	$333	48	$19,074	$397	14,610	4,535	4,722	$1,729,060	$366
1899 .	835	490,690	587	41	24,639	601	14,496	8,012	4,077	2,540,470	623
1900 .	915	600,160	656	40	27,651	691	18,234	10,245	4,336	2,939,345	678
1901 .	677	384,255	568	49	30,264	618	19,674	14,932	4,634	2,782,855	601
1902 .	452	263,180	582	50	30,600	614	19,178	16,779	4,462	2,661,460	596

Year.	Germany. (*e*)			Japan. (*b*)	Singkep (*f*)	Straits Settlements. (*g*)	Tasmania. (*b*)			Total Metric Tons.
	Metric Tons.	Value.	Per M. Ton.	Met. Tons.	Metric Tons.	Metric Tons.	Metric Tons.	Value.	Per M. Ton.	
1898.........	993	$372,252	$375	43	685	46,635	2,038	$705,810	$346	75,211
1899.........	1,481	870,750	500	18	678	46,679	2,275	1,355,433	596	78,592
1900.........	2,031	1,332,750	651	12	575	46,795	2,061	1,349,165	655	85,244
1901.........	1,451	849,000	585	14	793	47,728	1,818	1,062,710	584	91,760
1902.........	2,766	1,694,000	614	..	...	47,226	1,989	1,189,140	597	93,002

(*a*) From *Report* of Secretary of Mines and Agriculture of New South Wales, which is the only State that produces metallic tin. Tin ore is produced in Victoria, Queensland, South Australia and Western Australia, but its metal contents are reported in the productions of other countries. (*b*) From official reports. (*c*) Total sales in Java and Holland. (*d*) Exports. (*e*) Mostly from foreign (Bolivian) ores treated in Germany. (*f*) Sales in Holland. (*g*) Shipments to Europe and America, except for the years 1901 and 1902, for which the production returns as reported in the British Colonial Reports have been used.

Australia.—The total product from the mines of New South Wales during 1903 was 752 long tons of metallic tin, valued at £95,463, and 547 long tons of tin ore, valued at £29,430. The total value of £124,893 compares with the 1902 total of £53,706. In addition to the above there was produced, from ores imported into the State, tin to the value of £115,913. The noteworthy increase in production was largely due to success in the Tingha division, though the Emmaville, Deepwater and Wilson's Downfall divisions were also prosperous. There was a marked increase in the use of dredges, and the recovery by this means amounted to 244 long tons, valued at £20,100, the saving in the Tingha division, where five plants worked, being placed at £15,532. The Cope's Creek Dredging Company saved about 150 tons, valued at £12,445, and the New Wylie Tin Dredging Company saved £4,229 in value of tin ore. Promising lodes have been opened on the Inverell road, a mile and a half from Tingha, and at Red Hill and Stannifer, in the same locality. In the Emmaville division 150 Chinese have been kept busy sluicing tailings which had been cast aside in previous years. Considerable abandoned ground has been worked profitably, owing to the increased price obtained for tin and to improved methods.

STOCKS OF TIN IN ENGLAND, AMERICA AND HOLLAND. (a) (IN LONG TONS.)

	1897.	1898.	1899.	1900.	1901.	1902.	1903.
Stocks, December 31—							
Stock of foreign in London	15,146	8,110	5,486	4,286	5,114	4,557	4,283
Foreign landing in London	673	165	1,212	1,297	689	712	510
Straits afloat for London, including wire advices	2,500	1,050	2,900	3,835	2,780	2,845	2,025
Australian afloat for London, including wire advices	600	400	450	350	522	518	504
Banka on warrants in Holland	2,877	2,228	1,160	837	696	644	1,940
Billiton in Holland	1,328	1,036	470	330	329	60	12
Billiton afloat for Holland	1,193	1,322	1,050	350	440	333	590
Straits stock in Holland	377	454	100	60	30	....	314
Straits afloat for Holland	100	215	....	....	....	....	....
Straits afloat for Continent	600	560	450	590	873	650	550
Bolivian in Liverpool	710	300	550	495	846	184	32
Total stocks	26,104	15,840	13,828	12,430	12,319	10,503	10,760
Estimated stock in America and quantity floating	4,500	4,300	2,500	2,600	6,050	4,450	3,220
Grand totals	30,604	20,140	16,328	15,030	18,369	14,953	13,980
Trading Co.'s reserves of unsold Banka stock in Holland	4,333	3,213	4,353	5,347	7,251	1,466	1,526

(a) From the annual metal circulars of William Sargant & Co. and A. Strauss & Co.

In the Deepwater division an excess of water caused some suspension of work. The Silent Grove mine, the most important in this division, has yielded black tin averaging eight hundred weight to the long ton of ore raised. The workings there have been advanced about 100 feet. The Nine Mile Deep lead has not been worked. The expectations that work in the Broken Hill division would be carried on actively were not realized, and most of the leases have been cancelled. Although no great extent of new ground is being taken up, yet the general indications are that the increased output will be maintained.

The production of tin ore in Queensland in 1903 showed a marked increase, being the largest since the discovery of the Stanthorpe and Herberton fields. The total was 3,708 long tons, valued at £243,149, as compared with 2,085 tons in 1902, valued at £116,117. The unusually heavy rainfall assisted a notable increase in the product of stream tin, which in the Heberton district alone was valued at £45,287, as against £7,835 for 1902. The Walsh and Tinaroo field this year furnished more than one-half the output, Irvinebank being the most prolific centre, largely because of the output of the Vulcan mine, which reached a value of £24,560. The Vulcan main shaft has been sunk a depth of 900 feet, and a drive has been begun to intersect the lode. The Lancelot group of mines yielded a total value of £15,102, most of the product being taken from the 150-foot level. This company is erecting a new mill. The Stannary Hills mines yielded ore to the value of £15,848. The Coolgarra Company, after taking out tin to the value of £6,185, closed down its mines in September, owing to the poor ore obtained, especially from the Alhambra deposit.

The Kangaroo Hills mines yielded a value of £6,493 of black tin and £15,-410 of stream tin. Smith's Creek Proprietary mine was a disappointment, the 100-foot level producing nothing, and the shaft is being sunk deeper. The Great Northern mine, after two years, has shown a lode at 700 feet. At Watsonville, the Cuprite Company has met with encouragement in the Kangaroo, Lomond and Western fields. The New Era Tin Mining & Milling Company has acquired several abandoned mines at Bakersville, and will operate them for low-grade ores. At Reid's creek what are believed to be rich lodes have been opened. The ore carries in veins cutting granite and slate, and is said to be very rich in places. From one vein 5 ft. wide material was mined which carried 18 per cent black tin, while another vein was found of still larger size that carried rich ore. Several properties in the vicinity are under development. The high-grade ore at present is being transported in wagons to Irvinebank for treatment. The Waverley Company and Mount Brown Tin Mining Company in the Kangaroo Hills field have adopted the policy of treating stone for the public, which stimulates the search for new lodes. Two dredging companies have secured control of extensive tin-bearing areas for the purpose of treating the alluvial deposits with modern appliances. These are the Stanthorpe and the Broad Water companies, both of which have secured dredges at large expense. So far the work of the former has not been markedly successful, while the latter's dredge is out of commission. It has been suggested that smaller dredges could be used to better advantage.

Austria.—There was a production of 34 metric tons of tin in 1903, valued at $21,918. The output of tin ore amounted to 57 tons, an increase of 10 tons over the returns for the previous year.

Bolivia.—According to Juan B. Minchin the mining of tin in the vicinity of Orouro, Bolivia, made considerable progress during the year 1903. The output of tin concentrates or barilla for the year amounted to 3,721 tons, averaging from 64 to 71 per cent metallic tin. This production was divided among five mines, the largest of which is owned by Abelli & Company, of Avicaya. The mine is opened by a shaft of 95 meters depth, which is provided with a steam hoisting engine. The ore is crushed in a stamp mill and

The Engineering and Mining Journal, February 11, 1904.

is then concentrated by jigs, buddles and Wilfley tables. The Huanuni mine has reached a depth of 80 meters. The crushing machinery consists of a 10-stamp mill and its capacity is to be doubled by the addition of 10 more stamps. The Chuncho mine is a comparatively new enterprise. It is supplied with a mill of 10 stamps. At the Uncia mine the ore is crushed in part by small rolls and in part under rocking stone, and the concentration is effected with a Wilfley table, jigs and round buddles. The company is building a wagon road 45 miles long to the nearest railroad station, and will erect a new plant near the mine. The Quinsa Crur district in the province of Inquisivi has received a good deal of attention recently and important deposits apparently exist. Little development work has been done as yet owing to the scarcity of capital and defective means of transport. The mines of the district are situated in the great Cordillera and have an advantage over most mines of Bolivia in that there is an ample supply of water for power purposes.

Germany.—The production of tin ore in 1903 was 111 metric tons. The German smelters turned out 3,052 metric tons of tin, valued at $1,849,250, as compared with 2,766 tons, valued at $1,694,000, in 1902. A large part of this production was obtained from Bolivian ores. In addition to the total for 1903 there was a production of 371 tons of tin obtained from the treatment of tin scrap by electrolytic processes.

Malay States.—There was a slight increase in the output of tin in the Straits Settlements during 1903. From figures received in advance of Government reports it appears that the total output in 1903 was 50,017 long tons, as against 46,480 in 1902. The production of the individual States during 1903 in long tons was: Perak, 25,958; Selangor, 17,461; Negri-Sembilan, 5,089, and Pahang, 1,509. The following table shows the final returns for 1901 and 1902:

States.	1901.			1902.		
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
Perak	22,920	23,288	$12,462,750	24,159	24,547	$14,133,015
Selangor	18,010	18,299	9,792,935	16,569	16,835	9,692,855
Negri-Sembilan	4,478	4,550	2,434,910	4,376	4,446	2,559,960
Pahang	1,566	1,591	851,510	1,376	1,398	804,375
Total	46,974	47,728	$25,542,105	46,480	47,226	$27,190,235

About 60 per cent of the world's tin supply comes from the Malay States, most of it being obtained from alluvial deposits. During recent years there has been an increase in lode mining. The principal lode mines are on the eastern side of the Settlements and belong to the Pahang Corporation and the Pahang Kabang, Limited[3]. These are situated about 40 miles above the port

3 'Tin-Mining in the Straits Settlements,' by W. T. Saunders. A paper read before the Institution of Mining Engineers, 1904.

of Kwantan, on the river of that name. Communication between Singapore and Kwantan is maintained by steamer, but owing to the shallowness of the river the remainder of the journey is by Malay boats of not over five tons capacity.

The principal workings of the Pahang Corporation, Limited, are known as Willink's, Nicholson's, Bell's North and Bell's South. Another valuable lode is Pollock's, where there is a 520-foot shaft, but this is not being worked at present owing to deficiency of equipment. The same is true of the Jeram-Botang lode, where a 300-foot shaft is idle, awaiting the completion of a tramway. This corporation controls an area of about 500 square miles of territory leased from the Colonial Government, to which is paid a royalty of 5 per cent.

The Pahang Kabang, Limited, maintains its principal workings on Fraser's lode, where a deeper shaft is now being sunk. A second shaft is also being sunk by this company on the Myah lode.

The tin-bearing lodes occur in slate and usually have an east and west strike. They vary greatly in thickness, merging gradually into the country without well-defined walls.

The stone raised from the mines of both companies is crushed in the same mill, being conveyed from the mines by tramways. The stamp battery at the mill has 60 heads of 850 pounds, and the average monthly crush is about 3,500 tons. The stone from the workings of the Pahang Corporation averages from 2 to 2.75 per cent black tin, while that from the Pahang Kabang carries rather less. The oxide runs about 71 or 72 per cent metal.

Wood is used almost wholly for fuel, being obtained by contract with Chinese, at a cost of 10 to 12 shillings a cord. The wood is soft and of poor quality, and this, together with the difficulty of getting an adequate supply of wood in the wet season, has resulted in the purchase of some coal from Singapore.

The working costs at the mines fluctuate considerably owing to the varying rate of exchange of the currency used in the country. The average cost per ton of crushed stone, with the dollar at 1s. 9d., is about as follows: Development, 3s. 6d.; mining, 7s.; dressing, 4s.; general expenses, 7s..; total, £1 1s. 6d.

The production of one ton of black tin costs from £45 to £60. The smelting is done at Singapore, by the Straits Trading Company, which handles nearly the entire output of the country, producing over $100 tons of metal daily.

Chinese labor is commonly employed, the native Malays being generally deemed useless, except for work in the river boats and finding wood. Agents in Singapore furnish laborers at a cost of £5 to £6 each, under agreements to work 300 days. They receive food, clothes, but little money, and at the close of their contracts usually engage as free laborers at about 8d. per day.

Mexico.—The Sain Alto tin deposits, which are situated in the State of

Zacatecas, are described by J. Nelson Nevius[4]. The tin occurs in association with chalcedony, the country being rhyolite. The ore which is cassiterite weathers out from the enclosing rock and is concentrated in the deep ravines. The native ranchmen during and after the rainy season search the ravines and recover the ore. Nearly all of the ore is picked by hand from crevices in the rocks, from which the streams flow. At Rancho de las Cuevas, near Sain Alto, the ore is smelted in stone furnaces with charcoal as fuel. The furnace consists simply of a fire-box about 4.5 ft. high and 10 by 5 ins. in section, tapering slightly downward, and is lined with refractory clay. At the bottom an opening allows the metal to run out upon the ground as fast as it melts, and on the opposite side a tuyere enters about 8 ins. above the ground, the blast being supplied by two circular rawhide bellows worked by hand. The grade of the ore as smelted is about 40 per cent metallic tin. The output amounts only to a few tons each year.

South Africa.—The discovery of lode tin in the Transvaal was reported in August, 1903. The locality is on the eastern border of the Transvaal, near the edge of the South African plateau. The principal formation is granite, which is overlain in places by schistose rocks, and the tin-bearing veins occur near the contact. Three lodes have been discovered. Samples show the presence of 3.5 per cent tin, the oxide assaying about 67 per cent metal.

United Kingdom.—The report of the Doleoath Mine, Ltd., for the half year ending December 31, 1903, shows total receipts of £64,813 and working costs of £49,529. The gross income was less by £4,950 than in the previous half year, while there was an increase of £497 in the working expenses. The net profits, after deducting royalties and allowance for depreciation of plant, were £12,003, the smallest since 1898. During 1903 the sum of £17,480 was spent on new plants, shaft-sinking and development. The results obtained by the company for several years past are shown in the subjoined table:

Six Months.	Tin Ore Crushed.	Black Tin Sold.	Product per Ton of Ore.	Average Value per Ton of Ore.			Average Price per Ton of Black Tin.			Amount Realized.
	Tons.	Tons.	Lb.	£	s.	d.	£	s.	d.	£
June 30, 1898	38,089	1,140	67.07	1	3	8	39	16	4	45,221
December 31, 1898	40,608	1,162	64.10	1	6	10	46	18	0	54,497
June 30, 1899	41,101	1,037	56.57	1	13	8	66	12	7	69,222
December 31, 1899	41,639	1,040	56.00	1	19	8	79	7	11	82,651
June 30, 1900	45,102	1,043	51.80	1	28	3	82	15	4	86,364
December 31, 1900	43,254	960	49.76	1	15	11	80	18	2	77,750
June 30, 1901	47,603	1,001	47.14	1	10	8	72	19	10	73,132
December 31, 1901	48,975	1,033	47.28	1	8	10	68	7	6	70,676
June 30, 1902	48,155	934	43.48	1	7	10	71	17	1	67,168
December 31, 1902	52,295	893	38.28	1	4	9	72	8	4	64,716
June 30, 1903	47,899	863	40.39	1	8	11	80	3	6	69,251
December 31, 1903	51,011	876	38.47	1	5	2	73	5	8	64,200

Toward the close of 1903, exploitation in the bottom workings was largely suspended, owing to an influx of water due to heavy rainfalls. The surface

4 The Engineering and Mining Journal, June 20, 1903.

equipment is to be improved by a light railway, ore bins and other equipment.

The Carn Brea & Tincroft Mines, Ltd., during the first half of 1903 treated 23,980 tons of stone for a yield of 287 tons black tin, an average of 26.85 lb. per ton of stone. The total receipts were £21,334, affording a profit of £1,680.

The New York Tin Market.

The average price for tin in New York during 1903 was about 1.5c. per lb. higher than during 1902, the article being in a strong position in the relation of supply and demand. Production in the Straits remained about stationary. The Banka production for the fiscal year of 1902-1903 was announced by the Dutch Government as 10,400 tons, against which 15,000 tons were sold, making 4,600 tons out of stock.

The market in 1903 opened rather actively, with the quotations at 26.75 to 26.875. Stimulated by speculative buying both here and abroad, prices advanced by leaps and bounds until 28.5c. was reached. Reports regarding smaller shipments from the Straits and reduced sales of Banka tin caused another advance to 29.25 at the end of the month. After a temporary lull in the demand, consumers again started to buy, and the closing quotations in February were given as 29.625c.

At the beginning of March tin again made good its reputation as the most erratic metal on the list. The reported decrease of 1,700 tons in the visible supplies for the month of February, coupled with heavy shipments to the United States, was sufficient to advance values abroad nearly £5 per ton within a few days. The Banka sale went at a surprisingly high level and led to a fresh outburst of speculation. The United States market quickly responded and quotations were marked up to 30.75c. At these prices both consumers and dealers restricted their purchases, covering only immediate requirements. The market consequently became dull, and under free selling from the East prices sagged, the metal being freely offered at 29.5 by the beginning of April. Heavy arrivals from London, as well as from the Straits, caused the metal to sell below the parity of the foreign market during the rest of the month.

While at one time during May 30c. was paid, 28.5c. was the highest figure obtainable during the month of June, the article suffering from the poor European demand. During July the market ruled steady at about 27c., but in August traders took advantage of the scarcity of spot tin and worked prices up to 28c. for early delivery and 27.5c. for futures.

The official announcement that the Banka sales during 1904 will be for only 55,000 slabs each, being equal to a total of 11,500 tons, which is a reduction from the current year of about 3,500 tons, fell rather flat, having already been discounted to a large degree.

At the end of September prices declined to 26.62c., at the end of October to 26c. and at the end of November to 25.25c. The course of the market during

December was rather erratic, but on the whole the tendency was toward higher values, especially after cables were received from the Straits, advising continued speculative buying for account of Chinese in Penang and a shut-down of the smelting works of the Straits Trading Company for a week, on account of the ore coming slowly forward from the mines. The movement culminated in a quotation of 29.25 after the Christmas holidays. The closing prices for the year were 28.625 to 28.75 for spot and futures.

AVERAGE MONTHLY PRICES OF TIN PER POUND IN NEW YORK.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
1899 ...	22.48	24.20	23.82	24.98	25.76	25.85	29.63	31.53	32.74	31.99	28.51	25.88	25.12
1900 ...	27.07	30.58	32.90	30.90	29.37	30.50	33.10	31.28	29.42	28.54	28.25	26.94	29.90
1901 ...	26.51	26.68	26.03	25.93	27.12	28.60	27.85	26.78	25.31	26.62	26.67	24.36	26.54
1902 ...	23.54	24.07	26.32	27.77	29.85	29.36	28.38	28.23	26.60	26.07	25.68	25.68	26.79
1903 ...	28.33	29.43	30.15	29.81	29.51	28.34	27.68	28.29	26.77	25.92	25.42	27.41	28.09

The London Tin Market.

The year commenced with a visible supply of 14,769 tons, including a stock in London of 4,557 tons, the ruling price being £120 10s., cash. Values quickly rose to £133 10s., but eventually closed at about £3 below the highest. The chief cause for this improvement was speculative buying, based on the assumption that the quantity of Banka to be offered at the sale in Holland would be reduced, owing to the strike of dock laborers, and to the idea that production in the future would decrease, whilst the chances were in favor of consumption increasing.

Statistics at the commencement of February showed a big reduction, the London stock standing at 3,872 tons, the visible supply being estimated at 16,151 tons, and prices again moved upwards, until £139 was paid for cash. America came into the market and bought large quantities both for cash and forward shipment, and there was considerable speculative buying of three months' metal, on the idea that consumption in America would increase largely.

By the beginning of March the London stock had been reduced to 3,221 tons, the total visible supply standing at 14,243 tons. The market was active, but prices moved somewhat violently, owing to fresh liquidations of speculative holdings. Large sales of Banka by the Dutch Government, and heavier shipments from the Straits than were generally expected were both important factors in swaying the market, which was peculiarly sensitive, owing to the small stocks available for the speculative medium, which at the beginning of April amounted to only 2,212 tons; the total visible supply, however, being somewhat heavier at 17,629 tons. The tone of the market quieted down somewhat, and after £139 for cash, touched £134 10s., but rallied before the month was out to about £137. The chief bulls were able, owing to the small supply of warrants, to manipulate the spot market with comparative ease, and large lines were taken up. Considerable uncertainty was caused as to the probable future supplies, owing to the official notice issued that the Banka production for the year 1902 had been only 10,400 tons, while sales had been made at the rate of 15,000 tons yearly, clearly showing that the reserve stock held in the Dutch Indies had been seriously drawn upon, and it was generally thought that sales would have to be curtailed. Americans continued to buy, but not on a large scale, their purchases having been sufficient to meet their requirements for some time ahead.

May saw a further reduction in warrant stocks, which stood only at 2,031 tons on the first of the month, the visible supply also being reduced to 15,604 tons. Prices gave way sharply, owing to continuous and heavy selling by a prominent operator, and down to £124 10s. was accepted for cash. The prominent bulls were quite unable to stay the decline, and the tone at the end of the month was heavy, at about this figure. Consumption at this time showed signs of dullness, both in Europe and America, and although at the beginning of June, London stocks were again lower at 1,970 tons, the visible supply had increased to 17,701. Values moved between £125 and £130, mainly owing to speculation, consumers not showing much inclination to buy.

July opened with the London stock standing at 2,235 tons, the visible supply being reduced to 16,070 tons. The market continued to be of a professional character, and renewed onslaughts were made by the chief bears, who were again successful in driving prices downwards, until about £119 15s. was accepted for three months; but cash metal, which was firmly held, did not suffer to the same extent, only declining to £122. The tin-plate trade at the time was bad, and English consumers were only moderate buyers. But America sent orders over toward the end of the month, and rather more speculative buying was indulged in, principally on Continental account, induced by the announcement that the Dutch Government would sell 3,300 tons less in 1904 than in 1903. This buying caused an improvement to £128, cash, and £124 10s., three months.

The visible supply at the beginning of August had increased to 18,102 tons, London stock also being augmented considerably, and amounting to 3,556 tons. This increase in stocks was a bad feature, and prices fell away considerably during the month, although at first there was some artificial firmness, due to the great scarcity of cash warrants, which at one time commanded £130 10s.; but with renewed selling, a falling off in trade in America and a reduced demand from the Continent, there was a smart decline to £123 5s., cash, and £121 10s., three months, and the month closed at only a shade of advance from the lowest level.

September statistics gave the visible supply at 17,538 tons, the London stock, however, being increased to 4,651 tons. This constant piling up of stock in London caused a free market in spot metal, resulting in the disappearance of the backwardation in forward prompts, and a small contango had to be paid for forward before the month closed. American and English stock markets being demoralized had a bad effect on this metal, and there was heavy selling by stale bulls, which forced values to £111 10s., cash, and £112, three months, which, however, proved to be the lowest mark of the year, and there was a recovery to £115 5s., cash, and £115 15s., three months. Consumption was restricted, and in the all-around unsettled state of trade and finance buyers withheld their orders until absolutely forced to purchase.

A further increase in both the London stock and visible supply was declared at the beginning of October, the former standing at 5,053 and the latter at 18,158 tons. The lower values brought forth a better demand from European consumers, and there was large speculative buying in the East and on the London exchange, presumed to be for Chinese account. Closing values for the month were £118 5s., cash, and £118 15s., three months.

November commenced with heavy reductions in London stocks, which stood only at 3,886 tons, the visible supply also being lowered to 15,549 tons. Fluctuations were confined to narrow limits, but there was again very persistent buying by houses connected with the East. Continental consumers were free buyers, but prices did not improve, owing to these purchases being met by free sales from the Straits, which were probably induced by the weakness in silver, seriously affected the rates of exchange. America remained very passive, owing to the extreme uncertainty of the future of the iron and steel trades. Closing values were £118, cash, and £119 5s., three months.

December saw another shrinkage in London figures, which were given as 3,721 tons, the visible supply at the same time standing at 15,471 tons. The early part of the month witnessed a large speculative business, causing values to improve almost daily until £132 10s. was touched for cash. Eastern operators continued to buy, and outside speculators followed.

Later in the month a further sharp advance took place upon the receipt of news to the effect that the Straits Trading Company was shutting down their smelting works for a week. The closing quotations of the year are given as £132 15s. for spot, £133 10s. for three months.

Technology.

Separation of Tin and Wolfram.—The treatment of tin ore containing wolfram at Gunnislake Clitters is described by Edward Skewes.[5] The mine is situated on the Tamar river, which divides the counties of Cornwall and Devon. It was once worked on a large scale, principally for copper, but has been taken over recently by a German company which has installed a tin-dressing plant. The mill is of the California type and contains 25 heads of

5 The Engineering and Mining Journal, September 19, 1903.

stamps, a set of Cornish rolls, a crusher, eight Buss tables for sand, and Luhrig classifiers and vanners. From the mill the concentrates are taken to a Bruckner calciner which has a capacity of 10 tons per day. The concentrates contain about 12 per cent sulphur and arsenic. From the calciner they are carried to a magnetic separator, where they are gradually fed onto an endless belt and conveyed over two sets of adjoining magnets. The belt is about 2 ft. wide. Magnet No. 1 of 4-ampere strength attracts all the iron which was originally combined with the sulphur. As soon as the belt travels beyond the influence of the magnet, the iron drops into a bin. Magnet No. 2, which takes out the wolfram, is of 12-ampere strength. The capacity of the separator is about 5 tons per day. The magnets have no effect on the tin, which is carried by the belt to the tail roll and deposited. The tin is cleaned and prepared for the market in the usual manner. In the month of June, 1903, 2,540 tons of ore were milled, yielding 8 tons 16 cwt. of black tin, which sold for $380 per ton, and 19 tons 19 cwt. of wolfram, for which an average of $298 per ton was received. The total amount realized was $8,360, while the working expenses were $3,830. A large part of the material treated is the waste from previous operations.

Extraction of Tin from Dross.—According to a patent taken out by H. Brandenburg and A. Weyland[6], tin is separated from dross, slag and waste in the following manner: The powdered dross is mixed with water, and treated with a mixture of 1 part of hydrochloric acid with 2 parts, by volume, of sulphuric acid, no extraneous heating being needed; and the tin dissolved is separated from the filtered solution by known means. Sodium chloride may replace hydrochloric acid in the process; or the sulphuric acid may be replaced by sodium bisulphate, in which case the mixture will need to be heated.

Treatment of Scrap Tin.—It is reported that there are seven works in Germany operating the electrolytic process for recovering tin from scrap. Sodium hydrate is the electrolyte generally used. There is also one plant in Austria and one at Manchester, England. About 30,000 tons of scrap are treated annually in Germany, the supply being drawn from England, France and Switzerland, besides from domestic sources.

C. D. Brindley[7] has patented a process for recovering tin from scrap, which consists in heating the scrap in an oven upon stepped, inclined and perforated plates, to which a jigging movement is imparted by suitable machinery. In passing down the steps, the solder melts and flows through the perforations, and is collected from below. At the bottom of the steps the scrap passes into a hopper, and thence into a chamber, in which it is cut into strips by an arrangement of mechanically worked steel blades. After cleansing, and dissolving off the tin or zinc coating by a suitable acid, the shearings are

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6 English Patent, No. 16,377, July 24, 1903.
7 English Patent, No. 8,693, April 15, 1902.

moistened with a solution of an acid or mineral salt, and exposed in heaps to the air. When oxidised, the mass is ground, and the ferric hydroxide is calcined to form a pigment.

Determination of Tin in Tailings.—S. L. Mackenzie[8] describes a process for the determination of tin in tailings and slimes. From 1 to 5 grams, according to the amount of tin present, of the finely-powdered ore are heated for about 20 minutes with aqua regia, hot water is added, the solution filtered and the residue washed well with hot water. If tungsten or silver be present, the residue is then digested for 10 minutes with warm, dilute ammonia solution, and washed well on the filter with the same reagent. It is then dried, detached from the paper, and the latter burnt. The stannic oxide in the residue is now reduced to tin by heating to dull redness for 40 minutes in an atmosphere of coal gas. After cooling, the material is heated nearly to boiling for 20 minutes with strong hydrochloric acid and about 2 c.c. of a 10 per cent solution of permanganate, a further drop or two of permanganate solution being added towards the end. The solution is filtered, partly neutralized with sodium bicarbonate, and the tin precipitated by sulphuretted hydrogen. After standing for some time, the stannic sulphide is filtered off, washed well with ammonium acetate solution containing a little free acetic acid, dried, and the paper containing the precipitate burnt; the ash and precipitate are covered with a few drops of nitric acid, dried, and strongly ignited, and the stannic oxide is weighed.

Determination of Tin by Electrolysis.—According to H. Nissenson and H. Dannell[9] the following electrolytic method for the determination of tin in alloys and ores can be recommended as reliable and requiring little time or attention to details. From 0.5 to 1 gram of the alloy is dissolved by titrating with 3 c.c. of nitric acid (sp. g. 1.4), 12 c.c. of water and 1 to 2 grams of tartaric acid. A larger quantity of tartaric acid may be used if the alloy contains much tin. When the metal has dissolved, sulphuric acid is added to precipitate the lead, the solution concentrated till all the nitric acid is driven off, the residue diluted with water, filtered, and neutralized with caustic soda. Then 80 c.c. of a cold saturated solution of sodium sulphide are added, the solution boiled, and electrolyzed. If no lead is present, the nitric acid solution can be at once neutralized with caustic soda, and then treated with sodium sulphide as above. On electrolyzing, the antimony only is deposited. The solution, which contains the tin, is heated with 25 to 30 grams of ammonium sulphide, and electrolyzed with a current density of 1.5 amperes, deposition being complete in one to two hours. Should only small quantities of antimony be present, this will always contain a little tin, and it is necessary to repeat the electrolytic separation.

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8 Institute of Mining and Metallurgy, November 19, 1903.
9 *Zeitschrift für Elektrochemie*, 1903, pp. 760–765.

In the case of tin ores, 5 grams of the ore are fused with 15 grams of a mixture of 1 part of black flux (1 part of cream of tartar and 3 parts of potassium nitrate heated together in an iron spoon), 1 part of borax, 4 parts of sodium carbonate, and 1.5 parts of charcoal, the mass being covered with common salt. The regulus may contain, besides tin, also lead, copper and antimony, the tin being determined by the method already described. The tin can also be deposited from a solution of acid ammonium oxalate, instead of from ammonium sulphide solution, with a current density of 1.5 amperes.

ZINC.

By Walter Renton Ingalls.

The production of spelter in the United States in 1903 was 158,502 short tons, against 158,237 short tons in the previous year. This only partially represents the American production of zinc, since a large quantity of oxide is made directly from ores, and moreover a large quantity of ore is exported to Europe for smelting there. The following statistics have been compiled by the editors of The Mineral Industry:

PRODUCTION OF SPELTER IN THE UNITED STATES.

States.	1898.	1899.	1900.	1901.	1902.	1903.
Illinois and Indiana	46,693	49,290	37,558	44,896	49,672	49,526
Kansas	38,543	55,872	57,276	74,270	87,321	(a) 88,283
Missouri	21,063	15,710	20,138	13,083	10,548	9,894
South and East	7,805	8,803	8,259	8,603	10,698	10,799
Total tons of 2,000 lbs.	114,104	129,675	123,321	140,822	158,237	158,502
Total tons of 2,240 lbs.	101,879	115,781	110,028	125,734	141,283	141,520
Total metric tons	103,514	117,644	111,794	127,751	143,552	143,792

(a) Includes production of Colorado.

The output of zinc oxide in the United States in 1903 was 59,562 short tons, against 52,730 short tons in 1902. These totals do not include the product of the United States Reduction & Refining Company at Cañon City, Colo., which in 1903 made 4,500 short tons of zinc-lead pigment. The production of zinc oxide in the United States is derived partly from the franklinite ore of New Jersey, treated at works in New Jersey and Pennsylvania, which supply the eastern markets, and partly from western ores, treated at works in Wisconsin and Missouri, which supply the western markets.

PRODUCTION OF ZINC OXIDE IN THE UNITED STATES.

Year.	Quantity.		Value.		Year.	Quantity.		Value.	
	Short Tons.	Metric Tons.	Totals.	Per Short Ton.		Short Tons.	Metric Tons.	Totals.	Per Short Ton.
1898	32,747	29,708	$2,226,796	$68.00	1901..	46,500	42,266	$3,720,000	$80.00
1899..	39,663	35,982	3,331,692	84.00	1902..	52,730	46,929	4,023,299	76.30
1900..	47,151	42,775	3,772,080	80.00	1903..	59,562	54,034	5,005,394	83.69

IMPORTS OF ZINC AND ZINC OXIDE INTO THE UNITED STATES. (IN POUNDS.)

Year.	Sheets, Blocks, Pigs and Old.		Manufactures.	Total Value.	Oxide.	
					Dry.	In Oil.
1899..	2,985,463	$151,956	$14,800	$166,756	3,012,709	41,699
1900..	2,013,196	97,762	36,836	134,598	2,618,808	38,706
1901..	775,881	30,920	42,643	73,563	3,199,778	128,198
1902..	1,238,091	46,713	37,191	83,904	3,271,385	163,081
1903..	728,614	30,900	18,938	49,838	3,487,042	166,034

In addition to the imports given in the above table there were imported during 1903, 1,229,806 lb. of white sulphide of zinc, valued at $33,077.

EXPORTS OF ZINC ORE AND ZINC OXIDE FROM THE UNITED STATES.

Year.	Ore.			Oxide.		
	Short tons.	Value.	Value per ton.	Short tons.	Value.	Value per ton.
1899....	28,221	$725,944	$25.72	5,343	$366,598	$68.61
1900....	42,062	1,134,663	26.98	5,656	496,380	87.76
1901....	44,146	1,167,684	26.45	4,561	393,259	86.22
1902....	55,733	1,449,104	26.00	5,358	433,722	80.93
1903....	39,418	987,000	25.04	7,215	578,215	80.14

EXPORTS OF SPELTER FROM THE UNITED STATES.

Year.	Plates, Sheets, Pigs and Bars.		Wares.	Total Value.
	Short Tons.	Value.	Value.	
1899....	6,755	$742,521	$143,232	$886,753
1900....	22,411	2,217,963	99,288	2,317,251
1901....	3,390	228,906	82,046	310,952
1902....	3,237	300,557	114,197	414,754
1903....	1,521	163,379	71,354	234,733

Commercial Conditions.

The zinc business in the United States in 1903 was about as profitable as in 1902, high prices having prevailed throughout the year. A decline set in about the beginning of November, but, although it was rapid, the price did not fall below what would normally be considered a high level, and about the middle of December the market began to trend upward again. The high range of prices in 1903 was due to a strong demand for consumption, which kept the smelters busy, although the increase in smelting capacity was considerable. There were some labor troubles at Iola early in the summer, and later on there was a scarcity of furnacemen, which caused a comparatively few furnaces to be put on dead fire. Otherwise the full number of furnaces in the older plants was in steady operation, save those which had to be put out of commission for the usual periodical repairs, while several new plants came into operation.

The works of the Lanyon Brothers Spelter Company, at Neodesha, Kan. (a four-block plant), which was built in 1902, came into full operation in 1903. Early in the latter year it was purchased by the Granby Mining & Smelting Company. New plants of 1903 were those of the United States Zinc Company (affiliated with the American Smelting & Refining Company), at Pueblo, Colo., the Laharpe Smelting Company, at Laharpe, Kan., and the Chanute Zinc Company (Hess & Stuecke), at Chanute, Kan. The Pueblo works has six furnaces, each of 240 large retorts, of which the first was fired up in June. The Laharpe Smelting Company planned to have three blocks, with approximately 1,800 retorts; the first was put in operation about October 1, the second shortly after November 1; the third was not completed until the following spring. The works of the Chanute Zinc Company, a two-block plant, went into operation toward the end of the year. The Cherokee-Lanyon Spelter Company built a new block at Gas in February, and the United Zinc & Chemical Company, at Iola, completed a new block in November. The Edgar Zinc Company erected additional furnaces at its Cherryvale works, bringing the total number of retorts up to 4,800. The Illinois Zinc Company, at Peru, Ill., also constructed a new furnace, making a material increase in its capacity.

These various additions in the aggregate swelled the smelting capacity of the West very largely over and above what it was at the beginning of the year, and caused some alarm as to the immediate future of the business, especially in view of the halt in the demand which became manifest late in the autumn, the prospect of a further large increase in smelting capacity in 1904, and the probability that the Joplin district could not furnish the requisite supply of ore at any material reduction from the average price of 1903, which would prevent any considerable concessions to consumers, except at the expense of smelting profit. The new works which it was known would come into operation in 1904 were a four-block plant erected by William Lanyon at Caney, Kan., a three-block plant erected by A. B. Cockerill at Altoona, Kan., and a new plant erected by the Graselli Chemical Company at Clarksburg, W. Va. Moreover, it was rumored that certain of the old works at Pittsburg, Kan., might be put in operation again. Obviously there must be a large increase in consumption to employ fully the whole of this new capacity along with the old. However, it is to be remarked that the increase is not really so great as it looks, since the smelters are now treating a good deal of Colorado ore, for which more furnaces are required to produce a given quantity of spelter than from the richer Joplin ore.

Of the western smelters who use coal as fuel, there were in operation in 1903 the large plants at Lasalle and Peru, Ill., and the small plants at Waukegan, Wenona and Sandoval, Ill., Rich Hill, Mo., and Girard, Kan. The Carondelet plant of the Edgar Zinc Company, at South St. Louis, was operated as usual. The Collinsville Zinc Company, at Collinsville, Ill., resumed smelting, but after a few months gave it up. Outside of the Lasalle, Peru and Carondelet plants, the aggregate output of this group of works was small, the competition of the gas smelters permitting them to run only under exceptional conditions. In Indiana some smelting was done at Marion and Upland, but owing to the nearly exhausted condition of the gas supply the zinc smelting industry in that field is now practically ended. The history of Indiana is being repeated in the gas pools that have so far been drawn upon in Kansas, and the increasing cost of gas is materially enhancing the cost of smelting. This will lead eventually to a return of the smelting industry to the coal-fields.

The average price of spelter at New York in January was 4.865c. It rose almost without interruption until August, in which month the average was 5.725c. There was a slight recession in September, which tendency became more pronounced in October, and toward the end of the latter month there was marked weakness, which continued through November, the price dropping to 4.65c. New York, 4.50c. St. Louis at the end of the month. Toward the end of December there was a recovery to 4.875 New York. The value of sheet zinc fluctuated approximately with the price of spelter, opening at a basis of 6.65c., f. o. b. mills, advancing to 7.15c. in March, touching 8c. in May and falling to 5.75c. at the end of November. The last price afforded a margin of only 1c. per lb. over the price of spelter, which is less than usual. In the London market spelter ranged from £20 (4.34c.) to £24 (5.21c.). There were periods when the difference in price was nearly sufficient to permit imports, while at the end of the year the conditions had changed so that the export point came in sight. At certain periods there was difficulty in securing prompt railway transportation from the West, which caused wide differences to exist temporarily between the prices of metal on the spot in New York and orders for shipment from the works. At the beginning of the year there was a small stock of spelter at St. Louis, estimated at 3,000 to 5,000 tons. Before mid-year this had been exhausted, the markets were everywhere almost bare of stocks and the smelters had sold up far ahead. The slackening of demand in the last quarter of the year caused stocks to accumulate again, and at the close they were much larger than ordinarily. This showed a small falling off in the domestic consumption, the production having been about the same as in 1902.

In the Joplin market there was a small stock of ore on hand at the beginning of the year, and in order to bolster up the price an exportation of 1,000 tons was made in January, which, as it turned out, was a mistake, the value of ore for home smelting soon rising and remaining high until near the end of the year. Unless the London price for spelter be materially in excess of the New York price, exports can only be made at a loss, and, anyway, it would be better to export spelter than ore. The actual cost of shipping this 1,000 tons of ore from Joplin to Antwerp, including difference in assays, shrinkage, etc., was $8.30 per ton.

AVERAGE MONTHLY PRICE OF ZINC BLENDE ORE AT JOPLIN, MO. (IN SHORT TONS.)

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1896...	$24.00	$23.50	$23.00	$23.00	$21.50	$21.00	$21.50	$21.00	$20.00	$20.50	$23.50	$25.50	$22.33
1897...	22.12½	21.50	21.00	21.12½	21.60	21.87½	22.50	22.50	22.62½	22.75	23.50	24.25	22.28
1898...	23.00	22.50	23.00	24.62	26.50	28.50	28.00	28.37	31.00	33.70	36.25	37.00	28.44
1899...	32.25	43.37	43.40	51.50	50.50	45.50	44.20	45.00	43.75	43.50	35.00	36.00	38.54
1900...	30.23	29.36	28.45	28.42	26.92	25.00	24.23	25.67	24.25	24.25	24.45	25.40	26.50
1901...	23.72	23.96	23.70	24.58	24.38	24.22	24.68	23.88	22.82	21.63	26.15	28.24	24.21
1902...	26.75	27.00	28.00	28.85	29.23	34.10	34.37	32.50	33.00	33.58	32.10	29.25	30.73
1903...	31.50	32.50	35.75	37.75	36.60	36.50	36.00	36.00	35.50	34.40	30.75	30.00	34.44

NOTE.—The figures above given are the base prices for 60% ore.

The basis price for ore assaying 60 per cent Zn at Joplin was $31@$32 in January and $32@$33 in February. In March there was a rise from $33 to $37, and $38 was attained in April. In May the price declined to $36, and in June it ranged from $36 to $37. From the end of June until the middle of September it was steady at about $36, then falling to $35. In October the market was weaker, because of the declining tendency of the price for spelter, and ore sold at $35@$34. After the first week of November the market became demoralized and the price fell to $29. In order to support the market, the miners determined on the policy of operating their mills on part time, or closing down entirely, so as to restrict the output. A partial shut-down was brought about and remained in effect several weeks, but it failed completely in its purpose of influencing prices, did not even inconvenience the smelters, and had only the result of reducing the stock of ore somewhat and starting an exodus of miners who were thrown out of work. In alarm at the last effect, the shut-down was called off in the second week of December.

An important feature in the zinc business in 1903 was the shortage in the supply of ore from the Joplin district. In the first quarter the shipments amounted to 58,381 tons, an average of 4,491 tons per week. In the second quarter they were 63,964 tons, an average of 4,920 tons per week. In the third quarter they were 63,076 tons, an average of 4,852 tons per week. In the fourth quarter they were 49,311 tons, an average of 3,800 tons per week. The total for the year was 234,732 tons, which was valued at $7,914,665, an average of $33.72 per ton.

The decline in production in the Joplin district was due partly to the very wet weather in the spring, which interfered with operations to some extent, but the chief cause is obviously the inability of the mines of the district to do any more than they have been doing. It appears that the productive capacity of the Joplin district has attained its maximum, even if it be not already on the wane; the discovery of new mines has not kept pace with the exhaustion of the old ones. In 1898 the output jumped to 235,000 tons, rising further to 256,500 in 1899 and falling off to 242,500 in 1900. In 1901 it rose to 258,000, and in 1902 attained a maximum of 262,500, which, however, was but little more than 10 per cent gain over 1898. During all these years the price of ore has ruled high. In 1898 the average was $28.44; in 1899 it was $38.54; in 1900 it was $26.50; in 1901 it was $24.21; in 1902 it was $30.73. In 1903 the average basing price on ore assaying 60% Zn was $34.44 per ton. Previous to 1898 prices averaged much lower than during the last six years. It is evident, therefore, that the recent high level of prices has failed to stimulate the output of the district materially. The maintenance of the output has been due to the mining and milling of a lower grade of ore than could formerly be handled profitably, rather than to the discovery of new mines. A large proportion of the present output is being obtained from the so-called 'sheet-ground,' which is not only low grade, but also comparatively expensive to mine and mill. The mining of this character of ore deposit has materially increased the average cost of production in the district. This would indicate the necessity for a continuance of high prices, unless some new zinc-mining districts of importance be quickly developed. Naturally, attention was keenly directed toward other fields during 1903.

The most promising of the new fields appears to be southwestern Wisconsin, which is not really a new field at all, inasmuch as, historically, it antedates Joplin. Some ambitious ventures have been undertaken there in the past, but they have been baulked by various circumstances, among others by the difficult character of the general run of the ore; and mining has been conducted chiefly in a very primitive way, resulting in an output of about 15,000 tons of ore per annum, without much change from year to year. All this promises soon to be changed, since mining men from the outside, including a number from Joplin, have begun to investigate the field; and their opinion appears to be generally favorable. There seems to be no doubt that the Wisconsin mines have important resources of ore, from which a considerably increased output can be made by the introduction of improved methods of mining and milling. In fact, they made an increased output in 1903. In 1902 and 1903 about 12 concentrating mills of the Joplin type were built in the district.

The Wisconsin ore is not so good as the Joplin ore, not even when thoroughly cleaned, but it is nevertheless a high-grade ore. The associated minerals, especially the marcasite, make it rather difficult to separate clean blende, but this difficulty promises to be largely overcome by the application of improved methods of electrical separation. Some such plants have already been installed.

The commercial effect of an increased ore output from Wisconsin will be chiefly in favor of the Illinois smelters. The market for spelter is chiefly in the East, and consequently Wisconsin ore could hardly be carried profitably to Kansas for smelting. An additional supply of ore for the Illinois smelters, who have heretofore drawn heavily from Joplin, will tend, however, to leave the latter market more open to the Kansas smelters, who are also well situated with respect to the Colorado market. In 1903 the Kansas smelters treated a good deal of ore from the Rocky Mountains, three of them having been rather large buyers. At one time two plants at Iola were running exclusively on ore from the Far West, one of them being the Cherokee-Lanyon Spelter Company. The latter concern later on returned to the Joplin market, but after a short while reverted to its former practice of smelting Colorado ore alone.

The development of a market, both abroad and at home, for such zinc ore as can be produced in the Rocky Mountains, has created great interest in the exploitation of those resources. Leadville, Colo., has continued to be the principal point of production, but shipments have been made from Kokomo, Creede and Rico, in Colorado; from Park City and Frisco, Utah; from the Magdalena district, in New Mexico, and from the Slocan, British Columbia. The supply of this kind of ore is very large, indeed, and, for the present at least, the output is limited only by the milling facilities and the capacity of the markets. Although the value of the ore is comparatively low, because of its inferior character and the high freights that must be paid on it, the fact that it is commonly produced as a by-product in conjunction with silver-lead ore enables the miner to realize a satisfactory profit. At present this kind of ore is shipped to the spelter producers of Belgium, Kansas and Colorado, to the United States Reduction & Refining Company, which manufactures zinc-lead white at Cañon City, Colo., and to the Ozark Zinc Oxide Company, of Joplin, and the Mineral Point Zinc Company, of Mineral Point, Wis., both of which concerns make zinc-white. The works at Cañon City were destroyed by fire in 1903, but have been rebuilt, with increased capacity.

Further east there has been considerable activity in zinc mining in Arkansas, Kentucky and Tennessee, all of which States have made small outputs. The result of the year in Arkansas was rather disappointing. The existence of zinc ore at numerous points in the northern portion of that State has been known for a long time; one or two of the mines produced ore as far back as 10 years ago. It has always been claimed that a considerable output could be made as soon as railways entered the region. Now both the 'Frisco and the Missouri Pacific have built in, the White River branch of the latter having been opened in 1903, but the ore shipments have not yet attained a noteworthy figure. It is true that the railways have not gone directly to the mines, but they will not do that until a mining center which will warrant the construction be developed, and in the meanwhile the ore must stand a wagon-haul. Northern Arkansas is topographically rather rough, and the carting of the ore is more or less expensive, but if the ore cannot stand a $3 or $4 haul when the basing price is $35, Joplin, the outlook for mining on a $25@$30 base is not promising. However, several mills were built in Arkansas in 1903, and the prospect is for an increased production from the district in 1904, if the price of spelter be maintained at a high level. In Kentucky developments have been prosecuted more actively in the mines near Marion, from which increased shipments have been made, and the limits of the district have been extended.

In the East, the New Jersey Zinc Company completed the improvements at its Palmerton plant, with the exception of the blast furnace, which will be ready in 1904. The company contemplates the addition of 120 furnaces to its oxide plant. At Mine Hill the development of the great ore deposit was continued on the lines previously laid out. Two or three years will probably be required to complete this scheme.

Several mines were developed in the Holston River district of East Tennessee in 1903, where two companies erected concentrating mills, both of these operations being near Mascot.

Supply of Zinc Ore.

Great attention is being displayed in all parts of the world, but particularly in North America and Australia, to the development of new ore supplies, improvements in the methods of separating mixed ores having rendered commercially available many deposits that a few years ago were not so.

Arkansas.—The zinc and lead deposits of Northern Arkansas were described by George I. Adams.[1]

British Columbia.—Small shipments of concentrated blende have been made from the Slocan district to Iola and Antwerp. The freight rate to the former point has been reduced to $10 per ton; to the latter, a rate of $13 per ton is now made via Montreal. A characteristic of the Slocan blende is its silver tenor, which in some cases is quite high. The general occurrence of the ores has been described by Mr. A. C. Garde.[2] The presence of tin in some of the ore from British Columbia has recently been noted.

PRODUCTION OF ZINC IN THE WORLD. (*a*) (IN METRIC TONS.)

Year.	Austria	Belgium.	France.	Germany	Holland.	Italy.	Russia.	Spain.	United Kingdom	United States.	Totals.
1899.	7,192	122,843	39,274	153,155	17,202	251	6,331	6,184	32,222	117,644	502,298
1900.	6,742	119,315	36,305	155,799	16,698	547	5,963	5,611	30,207	111,794	488,981
1901.	7,558	127,170	37,600	166,283	17,144	511	6,090	5,354	29,877	127,751	525,338
1902.	7,960	124,780	36,282	174,927	20,760	485	8,280	5,569	40,244	143,552	562,839
1903.	*b*8,595	*c*155,297	*d*27,462	182,548	......	.....	9,901	.....	44,110	143,792	571,705

(*a*) Statistics compiled from official reports and the metal circular issued by Henry R. Merton & Co. (*b*) Includes output of Italy. (*c*) Includes output of Holland. (*d*) Includes output of Spain.

1 'Contributions to Economic Geology,' *Bulletin No.* 213, U. S. Geological Survey.
2 *Nelson Daily News*, April 3, 1904.

PRODUCTION OF ZINC ORE IN EUROPE AND AFRICA. (IN METRIC TONS.)

Year.	Algeria	Austria	Belgium	France	Germany	Greece	Italy	Norway	Spain	Sweden	Tunis	United Kingd'm
1898..	29,800	27,395	11,475	85,550	641,706	32,045	132,099	320	99,836	61,627	21,477	23,929
1899..	42,970	37,100	13,190	84,813	664,536	22,907	150,629	379	119,710	65,159	20,079	23,505
1900..	30,281	38,243	8,715	67,059	639,215	18,751	139,679	204	86,158	61,044	16,596	25,070
1901..	26,913	36,072	6,645	61,539	647,496	20,926	135,784	90	119,708	48,630	17,900	24,133
1902..	33,139	31,927	3,852	57,982	702,504	18,020	(*b*)149965	(*a*)	127,618	48,783	18,400	25,462

(*a*) Not reported. (*b*) Including 18,000 tons of copper, lead and zinc ore.

NOTE.—The above table is not complete, since Russia produces a rather large quantity of zinc ore, while Turkey furnishes a considerable supply, of which no recent statistics are available.

Colorado.—As in previous years, the chief production of zinc ore in this State was derived from Leadville. The output in 1903 was disposed of chiefly to American smelters, the European having been less active in the market than formerly. Prices ranged from \$5 to \$10 per ton, f.o.b. cars, for ore containing 40 per cent zinc, with variation of 50 @ 60c. per unit up or down. The concentrates now produced at Leadville assay Zn, 36 to 40 per cent; Fe, 15 to 18 per cent; Pb, about 3 per cent; and 4 to 8 oz. silver per ton. Some crude ore assaying 30 to 40 per cent zinc is also shipped. Practically the entire output of the Leadville mines is sold under contracts.

The shipments of zinc ore from Leadville in 1903 were probably in the neighborhood of 100,000 tons. According to the *Herald-Democrat,* they amounted to 80,213 tons, of which the Iron Silver Mining Company produced 65,713; the Yak Tunnel, 1,260; the R. A. M., 3,740; the Louisville, 2,500, and the Western Mining Company, 3,500. This statement is incomplete, since it includes only a very small proportion of the shipments of the Western Mining Company (Minnie and A. M. W. mines), which is the largest producer after the Iron Silver Mining Company.

The bulk of the zinc ore produced in Leadville comes from the sulphide extensions of the main ore-shoot in Carbonate hill and the southern ore-shoot in Iron hill. The latter extends through the Minnie and the Col. Sellers mines, passing from the latter into the Moyer mine of the Iron Silver Mining Company. The ore-body now shown in the Moyer mine is said to be 1,600 ft. in length with an average width of 300 ft. and thickness ranging from 4 to 125 ft. The ore is classified as (1) lead; (2) lead and zinc; (3) zinc, assaying as high as 40 per cent zinc; (4) pyrite, non-cupriferous; and (5) pyrite, cupriferous. All of the ore is argentiferous, and the pyrite is apt to carry a little gold. The various classes exist separately to a certain extent in the mine. The Moyer mine produces about 325 tons of ore per day, of which about one-third is broken out clean enough for shipment as it comes. The remainder is separated by hand-sorting, which is done on stationary tables, at each of which two men work, throwing the ore into cars standing conveniently near by. Each man sorts about 11 to 12 tons per day, which makes the cost less than 30c. per ton.

The ore raised from the Minnie mine is not so high grade in zinc. It is concentrated by crushing in Huntington mills and washing on Wilfley tables. The ore-slimes are conducted into bins lined with burlap, through which the water filters out. This has proved to be a very good arrangement for handling these slimes, loss of which is thereby avoided.

A considerable quantity of the Leadville ore is shipped to Cañon City and Denver, Colo., where there are mills equipped with magnetic and electrical separators. These mills make a higher grade of concentrates than the ordinary wet-crushing mills, but the cost of the process is considerably higher. At the best, the Leadville zinc ore, on account of its high iron content, is a comparatively inferior smelting material, but under the conditions of production and market there is a fair profit in it for both miner and smelter.

Several of the mines at Creede make considerable outputs of blende concentrates obtained as a by-product in milling lead-bearing ores. The output of one mill averages Zn, 47 per cent; Pb, 6.1 per cent; Fe, 1.3 per cent; 5.3 oz. silver and 0.42 oz. gold. That of another mill assays Zn, 58 to 60 per cent; Pb, 3.5 to 5 per cent; Fe, less than 2 per cent, and SiO_2, less than 2 per cent. The Big Kanawha Mining Company increased its milling facilities in 1903.

Illinois.—The lead and zinc deposits of Illinois were described by H. Foster Bain.[3]

Kentucky.—The zinc deposits of western Kentucky were described by E. O. Ulrich and W. S. Tangier Smith.[4]

Missouri and Kansas.—Frank Nicholson reported the production of zinc ore in the Joplin district in 1903 as 234,000 tons, against 262,500 tons in 1902, and the production of galena as 28,332 tons, against 31,615 tons in the previous year.[5] The falling off in the production is due to the fact that the old mines are being worked out much faster than new ones are being opened, while higher prices for all kinds of supplies and the necessity of working the hard sheet-ground deposits have so greatly increased the cost of production that there is but little encouragement to operate at current prices for ore, although these prices a few years ago would have been deemed highly satisfactory. The average mineral content of the crude ore now mined does not exceed 5 per cent, of which at least 1.5 per cent is lost in the tailings. The average cost of producing mineral assaying 60 per cent zinc in the Joplin district at the present time is not less than $30 per ton. In order to stimulate greatly production in the district a basis price of not less than $40 per ton will be necessary. This would permit the working of many sheet-ground mines that are now idle. It seems reasonably certain that a large proportion of the future output must come from the sheet-ground, which although lean is of wide extent and wonderful uniformity. The sheet-ground of the Joplin district is extremely hard mining. It is a fine-grained chert requiring the heaviest

3 'Contributions to Economic Geology,' *Bulletin No.* 225, U. S. Geological Survey.
4 'Contributions to Economic Geology,' *Bulletin No.* 213, U. S. Geological Survey.
5 The Engineering and Mining Journal, Jan. 14, 1904.

type of machine drills and large quantities of high explosives for its economic extraction. The average sheet-ground mine which furnishes ore for a 100-ton mill requires four machine drills and a weekly consumption of 1,050 lb. of powder, the actual amount of powder used varying from 800 to 1,200 lb. per week. The chert is extremely destructive of steel, and the wear on the drills is so great that they must be replaced every year. The roll-shells in the mill which last from 6 weeks to 3 months on ore from other mines are worn out in 26 shifts when working on the sheet-ground ore.

According to W. Spencer Hutchinson[6] the cost of mining and milling in the Joplin district is now 80c.@$1 per ton of crude ore, not allowing for interest on capital expended in development, or its redemption, when ore bodies of considerable size are worked, with little or no pumping to do, and the ore is dressed in mills of modern construction. Between those limits the cost varies according to the physical conditions, being highest in the hard sheet-ground and in the soft ground where a good deal of timbering is required. In the case of a body of soft ore under a hard roof the mining and milling may be done as low as 75c. per ton. The large areas of sheet-ground now worked at Webb City and Carterville yield from 2.5 to 5 per cent of concentrated blende. Mines yielding 7 to 10 per cent are now among the exceptions in the Joplin district, the majority being operated on ore which yields less than 5 per cent. According to the rate of royalty (from 10 to 25 per cent) ore yielding 5 per cent will pay when the basing price for concentrates is $22.20@$26.70, while ore yielding 4 per cent will only pay when the price is $27.80@$33.40.

Tennessee.—The zinc deposits of Tennessee were described by Arthur Keith.[7]

Wisconsin.—The lead and zinc deposits of southwestern Wisconsin have lately been exploited with a vigor never before displayed in the history of that district, with the result of an increased output already and the prospect of a more important increase in the near future. The occurrence of the ore has recently been described by Prof. U. S. Grant in a bulletin published by the Wisconsin Geological and Natural History Survey, of which the following is an abstract:

The Galena limestone contains by far the largest deposits of lead and zinc ore yet discovered in southwestern Wisconsin. The next important ore-bearing formation is the Trenton limestone. Ore has also been found in the Lower Magnesian limestone and in smaller amounts in the St. Peter's sandstone. The deposits now being worked, and those which have produced most ore in the past are confined to the Galena limestone and the upper part of the immediately underlying Trenton.

The important deposits of lead and zinc ore may be grouped under three classes: (1) Those which occur in certain cracks or crevices, and are in the

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6 The Engineering and Mining Journal, Feb. 25, 1904.

7 'Contributions to Economic Geology,' *Bulletin No.* 225, U. S. Geological Survey.

nature of vein deposits; they are termed crevice deposits and under them are included the flats and pitches of the district. (2) Those which occur in brecciated or very porous parts of the limestone, and may be termed honeycomb deposits. (3) Those which are disseminated in small particles through the rock and do not occur in fissures which were once, or are now, open; these are called disseminated deposits.

The main crevices of the district have a vertical position and strike approximately east and west. They are crossed by other fissures, running from north to south, and by certain quartering crevices which intersect the others at various angles. Most of the ore has come thus far from the east and west fissures, but commonly the ore deposits are richer, especially in lead, where two lines of fissures intersect. The vertical crevice deposits usually occur near the upper part, or in the upper two-thirds, of the Galena limestone. As they descend deeper into the Galena limestone they pass into a peculiar form of deposit known as flats and pitches; this form of deposit is characteristic of the district, and it seems certain that a very large proportion of the ore which will be mined in the next few years will be derived from these flats and pitches.

The honeycomb deposits comprise certain apparently brecciated and very porous parts of the Galena limestone, in which the cavities have been more or less filled by ores. These deposits occur sometimes as small openings or as enlargements of a crevice, but their main importance lies in the fact that they make extensive deposits, first along vertical fissures and second along flats.

In the lower parts of the mines which show the flats and pitches, there is found at times beds of rock containing scattered crystals of ore, mainly blende, but occasionally galena. Ordinarily this disseminated ore does not occur in quantity sufficient to be profitably worked, but there are certain localities where it is of decided importance. At present it is not possible to say how these deposits of ore trend. An important feature is that they contain, at least so far as developed, a smaller percentage of iron sulphide than do the ordinary deposits of the district; moreover, the rock in which they occur is in general considerably softer than the main Galena limestone, and so is easier to mine and crush. Already two mills have been built at mines of this character, and it seems probable that these disseminated deposits, which heretofore have never been worked to any considerable extent, will become an important factor in the production of the higher grade of ores from this district.

The zinc blende of Wisconsin varies in color from a light straw yellow, through brown to jet black, the black color being due to impurities, especially iron. In some cases, especially in soft clays, blende occurs in aggregations of small crystals with a berry-like shape; this has been designated as "strawberry jack." Associated with the blende are galena, pyrite and marcasite. The marcasite is much more abundant than the pyrite. Smithsonite and hydrozinkite occur, but the hydrosilicate of zinc has not been observed. Deduced from a theoretical consideration of the formation of these ore deposits, a general rule for the occurrence of the ores would be galena in the higher levels, then galena associated with smithsonite, then blende, and lower down the original sulphides, consisting of considerable amounts of marcasite and smaller amounts of blende and galena. In many mines it is indeed found that the ores grow poorer with depth. However, it is an open question as to whether the lowest levels of the mines of this district are richer in marcasite, although there is no doubt that such is sometimes the case. On the other hand, there are certain of the deeper mines, especially the Enterprise at Platteville, which show a considerable quantity of marcasite at certain levels below the level of ground water, but which lower down show richer masses of blende with only a small quantity of marcasite.

Mining has been carried on in this district for the last seventy years, and in many parts is still done in the same primitive manner that it has been for years past. There are still many lead and dry bone diggings which are worked only a few weeks or a few months in the year, when the owners are not engaged in the work of farming. It is only within the last few years that much mining has been done below the water level. Such as has been done seems to have demonstrated in a large number of cases that, below the old ranges which were worked in former years for lead ore, there are other deposits of zinc ore with a less quantity of lead. There are hundreds of old ranges, only the upper parts of which have been mined. Below many of them at least there are good reasons to expect as rich or richer deposits of zinc and of lead ore, and there are sufficient reasons for believing that the future will see more zinc ore produced from this district than has been produced in the past, though it is doubtful if the same statement can be made with reference to lead. The recent activity in mining in the district has developed a number of mines, operated on a more extensive plan than was formerly the practice, which have been able, by the introduction of machinery, to mine at a considerable depth below the level of ground water, although even these mines are not run on very extensive principles. The comparatively small expense and the somewhat primitive method of mining which is in vogue are necessary results of the cautious manner in which work has been resumed in this district during the past two years. There is no question but that the methods of mining will be improved, and larger plants installed. In fact, this has been done already in some cases.

In the early days, and still to a considerable extent in the smaller mines, the concentration was done by hand sorting and hand jigging. During the past two years 12 mines of the district have installed and now have in operation, or in course of construction, concentrating mills. These mills are equipped with crushers and jigs which enable them to turn out from 10 to 40 tons of concentrated ore per day. In jigging the ore, it is found possible to separate the galena very completely from the blende, but it is practically impossible to separate the blende and the marcasite. The consequence is that because of the presence of marcasite in all of the ores, except in some of the disseminated ores, the product of this district fetches a lower price than that of certain other districts. The presence of barite in the ore is also detrimental, but this is found only in small amounts and in few localities. Where hand sorting is resorted to it is frequently possible to separate considerable quantities of very pure blende, but at the mines which have mills it is not found economical to practice hand sorting. At the Trego mine, near Meeker's Grove, a roaster and magnetic separator have been installed, and it seems probable that other mines, especially those in which the marcasite percentage is high, will find it expedient to install similar apparatus.

In conclusion, it is to be said that the deposits of galena and smithsonite near the surface in southwestern Wisconsin are by no means exhausted, although they will not play so important a part in the future as they have in the past. Where such surface deposits have been worked there is good reason to believe that larger and more extensive deposits of zinc ore will be found below the water level. In the lower 75 ft. of the Galena limestone and the upper few feet of the Trenton, there probably exists a larger quantity of zinc ore than has yet been produced, and there is every reason to believe that the future will show the development of an extensive and important zinc mining industry in southwestern Wisconsin. There is a probability that other ranges

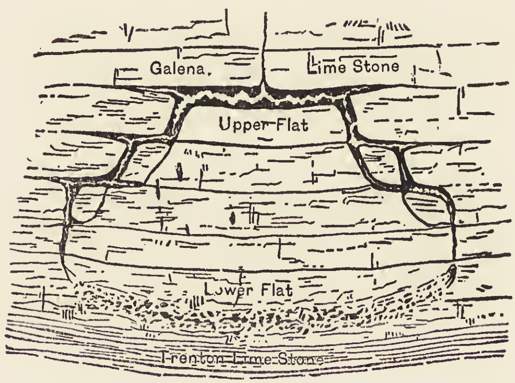

Fig. 1. Occurrence of Zinc Ore in Wisconsin. After T. C. Chamberlin.

will be discovered, but for the immediate future prospecting should be confined to those which have been productive near the surface. Ranges should be selected in which the level of the ground water is some distance above the base of the Galena limestone.

The possibilities of the Wisconsin mines, from the commercial standpoint, were discussed by Frank Nicholson.[8] He states that along the horizontal bedding planes of the limestone there are sheets of blende varying in thickness,

8 The Engineering and Mining Journal, Dec. 5, 1903.

the ore following down along the vertical jointing planes. (These are the "flats and pitches" referred to by other writers.) At the bottom of the deposit a sheet of blende is found, as a rule. The flats and pitches are apt to occur in a saddle-form, and the inclosed core of limestone, known locally as the "brangle," contains disseminated ore. An ideal cross-section, illustrating the occurrence, is shown in the accompanying engraving. Not infrequently the core shows secondary sheets of blende almost as important as those along the walls of the deposit. The ore lies in belts, called ranges, most of which trend east and west.

The ore deposits are probably of greater magnitude, on the average, than at Joplin. The Hoskins mine, for example, has a drift 700 ft. long on the north pitch, while the distance between the north and south pitches is about 400 ft. and the vertical depth from the top flat to the bottom flat is approximately 100 ft. This would indicate more than 1,000,000 tons of ore that may reasonably be expected from this mine, providing the grade of the entire core be sufficiently high. In those mines where the core is too poor to be mined and milled and only the flats and pitches are worked, the mine is exhausted with great rapidity.

The mills so far introduced in Wisconsin, of which about twelve have been erected and six are in operation, are of the Joplin type. They produce a mixed concentrate of blende and marcasite, which ordinarily has to be separated electromagnetically or electrostatically. The ore is usually expected to yield about 20 per cent of mixed concentrate, and about 10 per cent of high-grade blende after separation. Concentrates from the Hoskins and Trego mines, assaying 25 to 30 per cent Zn and about the same in iron, have been separated so as to yield a blende containing 57 to 61 per cent Zn and 2 to 4 per cent Fe. Concentrates assaying about 30 per cent Zn yield, by the Blake machine, about 47 per cent of blende assaying 59 per cent Zn. At the Enterprise mine, at Platteville, where the flats and pitches are well defined, the concentrates carry only about 10 per cent Fe and are marketed without further separation. Some of the Wisconsin ores are difficult to make quite clean of lead; some of them are easily cleaned.

Labor in Wisconsin is slightly lower than at Joplin, but less efficient. Transportation facilities are poorer. The first cost of the necessary mining and milling plant is somewhat higher. Mr. Nicholson concludes that there is little to choose between a mine yielding 10 per cent blende in Wisconsin and 5 per cent at Joplin. There is undoubtedly a great supply of ore in Wisconsin, but the development will be slow. The production at the time of writing was about 350 tons per week.

Italy.—The ore deposits of the Iglesias district, Sardinia, were described in a paper by Bergreferendar Duenkel,[9] an abstract of which was published in The Engineering and Mining Journal, of March 14, 1903.

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9 *Zeitschrift f. d. Berg-, Hutten-u. Salinenwesen im Preussischen Staate*, L, iii, 622.

New South Wales.—The high price for zinc and the success of the new methods of separation greatly stimulated production at Broken Hill, whence 20,754 tons of concentrates were exported in 1903 against only 1,260 in 1902. Magnetic separation and flotation processes are now extensively employed. The character of the flotation processes is described further on in this review. They appear to make a concentrate assaying about 45 per cent zinc, against 40 per cent zinc in the product of the magnetic separators. The Sulphide Corporation operated one furnace at its smeltery at Cockle Creek, and produced 286 tons of spelter in 1903. A vein of zinc ore, 18 ft. wide, assaying 40 to 50 per cent zinc, 5 per cent lead, and 3 to 6 oz. silver per ton, from which big developments are expected, was discovered in Bolaira parish.

Turkey.—The lead and zinc mines of Balia, operated by the Société Anonyme Ottomane, were described by George St. Ralli.[10] The mines are situated in the *vilayet* of Brousse, Asia Minor, about 100 km. from the sea, with which they have not yet been connected by railroad. The ore consists of galena, blende and pyrite, in a gangue of limestone and eruptive rock, averaging 10 to 20 per cent lead and 8 per cent zinc. The company's plant at Balia comprises a mill of 400 tons daily capacity, a Wetherill magnetic separator and a water-jacket lead furnace. The furnace is rectangular, 1 x 1.8 m., and has a daily capacity of 100 tons (75 tons ore and 25 tons slag). About 10 per cent of the charge is coke, which is poor in quality, containing 15 per cent ash and 10 per cent moisture. With good dry coke 8 per cent is sufficient. The slags produced contain 2 per cent lead, 20 grams silver and 10 per cent zinc per ton. An average extraction of 96 per cent of the lead and 98 per cent of the silver in the ore is made. The smelting costs, including roasting, are about 60 fr. per ton of ore treated. Milling costs about 3.8 fr. per ton. The present production approximates annually 10,000 tons of lead and 2,000 tons of blende. In 1903 the output was 63,000 tons of ore, yielding 7,600 tons pig lead, with an average content of 97.5 per cent lead and 1,950 grams silver per ton; 4,000 tons galena, assaying 70 per cent lead and 1,400 grams silver, and 1,900 tons of blende, containing 41 per cent zinc. The lead is transported to the coast at an expense of 20 fr. per ton, and is shipped to Frankfort, Germany, for refining.

The New York Spelter Market.

The year opened with spelter quoted at 4.375 to 4.40 St. Louis and 4.55 to 4.575 New York. These low prices soon attracted the attention of consumers, and the market advanced steadily from month to month, sharing in the general prosperity in evidence in the metal industries during the first half of the year. Spot metal commanded a premium at nearly all times, the trade suffering from freight congestion and inadequate transportation facilities during the lake and rail season. The floods in the West also seriously interfered

10 The Engineering and Mining Journal, Feb. 18, 1904.

AVERAGE MONTHLY PRICE OF SPELTER PER POUND IN NEW YORK.

Year.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
1899..	5.34	6.28	6.31	6.67	6.88	5.98	5.82	5.65	5.50	5.32	4.64	4.66	5.75
1900..	4.65	4.64	4.60	4.71	4.53	4.29	4.28	4.17	4.11	4.15	4.29	4.25	4.39
1901..	4.13	4.01	3.91	3.98	4.04	3.99	3.95	3.99	4.08	4.23	4.29	4.31	4.07
1902..	4.27	4.15	4.28	4.37	4.47	4.96	5.27	5.44	5.49	5.38	5.18	4.78	4.84
1903..	4.87	5.04	5.35	5.55	5.63	5.70	5.66	5.73	5.69	5.51	5.39	4.73	5.40

with shipments. Throughout the summer, values were well maintained at about 5.50 to 5.60 St. Louis and 5.70 to 5.80 New York, in spite of a falling off in the consumption caused by the various building strikes. In October, however, prices began to give way, the demand became rather slack and the few orders which presented themselves were eagerly competed for. From 5.15 St. Louis and 5.35 New York, which were the ruling quotations during the first half of November, the market declined to 4.50 St. Louis and 4.675 New York by the middle of December. The proximity of the domestic and foreign markets, the latter showing considerable strength, checked a further decline, and a rather active business developed, which carried the price to 4.70 to 4.75 St. Louis and 4.875 to 4.90 New York.

The London Spelter Market.

The year opened with an excellent consumptive demand for spelter, for galvanized iron and yellow metal, which manufacturers covered freely at the current rates of £19 15s. for ordinaries and £19 17s. 6d. to £20 for specials. Continental producers sold good quantities at gradually advancing prices, so that before the month was out the price of ordinaries rose to £20 5s., specials being held for £20 10s.

In February America sent over strong reports as to the market, and consumption in Europe being on a very large scale, there was a renewal of the upward movement, ordinaries rising to £21 12s. 6d. and specials to £21 17s. 6d. Dealers being well sold found difficulty in replacing their stock, while the continued big demand from all sources absorbed all that was available.

Business in March was on a still larger scale, and values were forced up to £24 for ordinaries, specials realizing about 2s. 6d. per ton more. Toward the end of the month the generally unsettled state of all markets, both trade and financial, caused a slight setback, the close being at about £23 2s. 6d. for ordinaries.

Early in April producers, who were fully sold, showed no signs of meeting the market, but second-hand lots held by Continental dealers were put on the market, and this, with bear selling, caused a drop on forward metal to £22 2s. 6d., but on renewal of buying by consumers there was a quick upward move to £22 17s. 6d. for ordinaries and £23 for specials. At the end of the month consumers showed but little interest, while second-hand lots continued to be offered cheaply, so that at the end of the month the price of ordinaries was reduced to £21 10s.

In May trade remained very quiet, leading to a decline to £20 5s. for ordinaries and £20 10s. for specials.

The first week in June witnessed a large demand from galvanizers, who made free purchases, so that values were quickly driven up to £21, but the cessation of this demand and very free selling by holders drove prices down again to about £19 15s. for ordinaries and £20 for specials.

July commenced with a somewhat better feeling, and a few buying orders sufficed to raise values to £20 15s., but Continental producers showing more inclination to sell and realizations of speculative holdings caused a drop to £20.

August opened quietly, but later on a good trade developed owing to better business in galvanized iron and yellow metal, and with producers holding for very high values, the price recovered to £21. Toward the end of the month the demand was very large, and full prices had to be paid for anything in the way of early delivery.

In September the rising market was checked by a fair amount of selling by Continental holders, but when this had ceased the unsatisfied demand was large enough to raise prices to £21 for ordinaries and £21 5s. for specials. Later in the month there was a decline, owing to inactivity on the part of buyers, and bad trade in sheet zinc.

Free selling by dealers caused the price in the early part of October to sag away to £20 2s. 6d. for ordinaries, but on an improved demand, chiefly from galvanized iron makers, there was a recovery to £21, a large business being done during the rise.

November found most consumers rather bare of material, as they had been purchasing only on a hand-to-mouth basis, but Continental dealers were free sellers, and showed some anxiety to get rid of their stocks, so that a fall took place to about £20 10s. for ordinaries and £20 12s. 6d. for specials. Most of the producers seemed willing to shade prices, and a fair business was put through at the lower level. During December the market developed considerable strength, and full prices were paid, especially for near delivery. The closing quotations were £21 10s. for good ordinaries and £21 15s. for specials.

Mechanical Separation.

The most important commercial results in the treatment of mixed sulphide ores have so far been achieved in improved methods for the mechanical separation of the constituent minerals, followed by smelting of the various products in the usual ways, and it is not unlikely that herein we have after all the most economical solution of the baffling mixed ore problem, except in special cases, including those of ores with high values in gold and silver. Four kinds of separating processes are now in use, viz.: (1) Carefully applied gravity separation; (2) flotation; (3) electrostatic; (4) electromagnetic.

Flotation Processes.—A new kind of ore separating process has been invented in Australia and put in practical application with successful results at Broken Hill, which may be appropriately classified as a 'flotation' process, inasmuch as the separation is effected by floating certain mineral particles to the surface of a bath, whence they may be skimmed off. Unfortunately it appears that there is likely to be litigation as to the patents covering these processes.

C. V. Potter, in 1901, discovered that very dilute acid solutions caused certain sulphides to rise to the surface. This is due to superficial attack by the acid, developing sulphureted hydrogen, bubbles of which cling to the sulphide particle and when sufficiently in volume float it to the surface. Pure sphalerite is not attacked by dilute sulphuric acid, but blende that is at all ferruginous is attacked. The specific gravity of blende is about 4, i.e., 4 grams will displace 1 cc. of water, wherefore a bubble of 3 cc. of sulphureted hydrogen will float 4 grams of blende; since 98 grams of sulphuric acid will produce 22.3 liters of sulphureted hydrogen at 0°C and 760mm., that quantity of gas should float 29,760 grams of blende, or, roughly, 300 times the weight of the acid. By heating the solution to near its boiling point a less quantity of acid is required on account of the expansion of the bubbles. In practice it is found that only the finest particles, such as slimed products, can be lifted by the tiny bubbles that attach to them. When two or more minerals are present they appear to form a couple and the bubbles transfer themselves to the electronegative. But, whatever be the true explanation, the action is almost instantaneous in separating zinc sulphide from Broken Hill ores.[10]

The Potter process is in use at the Block 14 mine, Broken Hill, where four machines are in operation. Their construction is such that when the bubbles lifting the mineral to the surface burst, and the mineral starts to sink again, it falls into V-shaped launders, in which they are conveyed away by traveling scrapers. Concentrates assaying as high as 49 per cent Zn are produced.

G. D. Delprat, general manager of the Broken Hill Proprietary Company, in 1902 patented the process which consists in making a solution of sodium sulphate of about 1.4 sp. gr., adding sulphuric acid, heating, and immersing pulverized ore. The blende rises immediately to the surface as a black scum, as high as 90 per cent being removed in a few minutes. The operation is conducted in a vat so arranged that the scum can be easily removed from the surface, while the gangue is drawn off from the bottom. The densification of the solution by means of salt cake gives a more speedy flotation and reduces the consumption of acid. Very little gas is said to be wasted. The Broken Hill Proprietary Company is erecting a large plant to apply this process.

In a subsequent patent, Delprat proposes to use nitric acid instead of sulphuric and increase the density of the bath by means of sodium nitrate.

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10 Donald Clark, THE ENGINEERING AND MINING JOURNAL, Jan. 21, 1904.

In separating material containing 17 per cent zinc, the Delprat process is said to make a concentrate assaying 43 to 47 per cent zinc, and tailings assaying only about 5 per cent, while the cost of the process is claimed to be very low.

A process which is somewhat similar to that of Delprat has been patented by William Jamieson and Francis J. Odling, both of Melbourne, Australia. In their process the pulverized ore is treated with chlorine water for the purpose of attacking the blende, the ore being then submitted to a vanning motion.[11] Experiments with this process are being made at the Block 10 mine, Broken Hill.

Electrostatic Separators.—A new class of ore separator has lately been developed and put in practical application, in which the principle of electrostatic repulsion is utilized. It has been found that many metallic sulphides and other compounds possess a high electrical conductivity, while the gangue minerals generally, and certain sulphides, e. g., zinc sulphides, are non-conductors. Now, when a conductive particle is brought in contact with an electrified body, it immediately assumes a similar charge, with the result that it is repelled, while non-conductive particles when brought in contact with an electrified body are unable to discharge their electricity and assume a charge similar to that of the body with which they are in contact, and are not repelled. Upon this principle a separation can be made. Particles of high conductivity are instantly repelled, while those of low conductivity are not repelled until sufficient time has elapsed to allow them to be pulled out of their original path and caught in a separate receptacle. The separation of two minerals does not necessarily require that one of them be a good conductor, but simply that there be a sufficient difference in their conductivity. Absolute dryness is of course an essential to good work.

It has been found by experiment that galena, pyrite, marcasite, chalcopyrite, pyrrhotite and magnetite among other minerals are conductors, while blende, either "rosin jack" or "black jack" is a non-conductor. This enables a separation of blende to be made from other sulphides, but may not permit a separation to be made between blende and calamine, or blende and limestone, though in many cases these separations can be made because of differences in the electrical properties of the minerals. Dark colored blendes can usually be separated from barite. The iron that occurs in many blendes as monosulphide does not appear to affect its conductivity, excellent separation being made of Leadville ore, in which the blende contains 7 or 8 per cent iron as monosulphide.

Irrespective of to whom the application of this idea may be due, its practical development must be credited to Prof. Lucien I. Blake and Mr. Lawrence N. Morscher,[12] while Mr. W. G. Swart[13] has been very instrumental in putting the Blake-Morscher process on a commercial basis.

11 United States Patent No. 750,034, Jan. 19, 1904.

12 United States Patents Nos. 668,791 and 668,792, both of Feb. 26, 1901.

13 The Engineering and Mining Journal, Jan. 24, 1903.

The Blake-Morscher separator is constructed of wood in substantially the form shown in transverse vertical section in the accompanying engraving. The ore distributed in the double hopper by means of a small screw conveyor

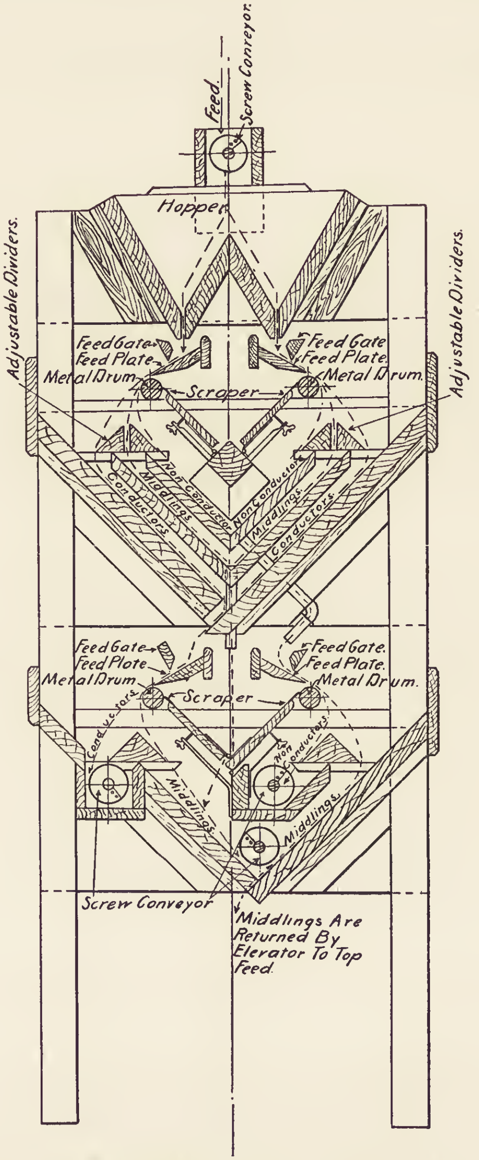

Fig. 2. Blake-Morscher Separator. Vertical Section.

is discharged over a suitable feed plate upon a metal drum or electrode (which is revolved). The conductors, non-conductors and middlings, which are repelled or non-repelled as the case may be, are separated by the adjustable dividers and fall into separate chutes, which convey them to another set of electrodes over which they pass, being separated thereby into final products, save the middlings, which are returned by a belt and bucket elevator to the top of the machine.

The capacity of the machine on any given ore is obviously a function of the length of the electrodes. The double machine, with 20-ft. electrodes, used for separating Wetherill middlings (Leadville ore) at Denver, Colo., treats about 10 tons of material per 24 hours, with a total consumption of about 1.5 h. p. The cost of such a machine is only about $800.

Many difficulties had to be solved in developing a practical apparatus, so little being known as to the application of static electricity. The proper distribution of the electric charge and the successful insulation of the high voltage currents in the face of the dust, moisture, and working conditions generally were among the problems solved. A simple means of controlling the effect of the violent fluctuations of the static charge was devised and the voltage was reduced from 250,000 to 10,000 or 20,000, corresponding to a spark of ⅛ to ¼ in., though the machines at Denver are operated with about ¾ in. spark. A static generator has been devised, which is constructed almost wholly of metal, with no glass whatever, self-exciting and able to run continuously in the open air without regard to atmospheric conditions and with no more attention than an ordinary dynamo receives.

The Blake-Morscher separator has given excellent results at the works of the Colorado Zinc Company, at Denver, where it is used for the treatment of Leadville ore, at the Silver Ledge mill near Silverton, Colo., at the Harris mill at Denver, and at Benton, Wis., where it is used for the separation of blende and marcasite obtained as a mixed concentrate by jigging. Leadville ore is separated into a zinc product assaying 50 per cent zinc and a lead-iron product assaying only 7 per cent zinc. Wisconsin concentrates assaying 18 per cent zinc are made to yield about 25.5 per cent of blende assaying 59 per cent zinc, and 74.5 per cent of marcasite assaying only 4 per cent zinc. Concentrates assaying 30 per cent zinc yield about 47 per cent of blende assaying 59 per cent zinc.

Clinton E. Dolbear,[14] of Boston, Mass., patented an electrostatic separator in which the ore particles are caused to fall in front of a pair of plates similarly charged with high-potential electricity, a third plate oppositely charged and inclosed by two non-conducting plates being placed between the first two. The ore particles that are conductors are repelled by the latter toward the middle plate, and are caught by suitable shelves, while the non-conducting particles fall straight into collecting hoppers. There are means for adjusting the positions of the various parts of the apparatus.

Alonzo H. Perry[15] also patented an electrostatic separator.

Magnetic Separation.—The Wetherill machine, improved by L. G.

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14 United States Patent No. 724,679, Apr. 7, 1903.

15 United States Patent No. 759,910, May 17, 1904.

Rowand, continues to keep the lead in this class of work, especially in the United States, though certain other separators, including the Mechernich and Ulrich have come into successful use abroad, while the Cleveland-Knowles and Payne are employed to some extent in this country.

The Mechernich separator has been in successful use at the Central mine of the Sulphide Corporation at Broken Hill for the last two years, 33,391 tons of zinc concentrates having been produced in 1903. During the first six months of that year, there were treated 27,376 tons of middlings, assaying 27.5 per cent zinc, which yielded 13,389 tons of concentrates, assaying 40.6 per cent zinc, showing a recovery of 69.9 per cent of the zinc in the ore. It is understood that the present plant (20 machines) is to be duplicated. The Mechernich separator has not yet been introduced into the United States, but is shortly to have a trial.

The Australian Metal Company employs the Ulrich separator, which has been substituted for the Wetherill. It is claimed to make a product assaying 45 per cent zinc out of middlings assaying 27 per cent zinc and effect a recovery of 84 per cent.

The Wetherill Separating Company reports the following number of its cross-belt separators (type E) now in use for separating zinc ore in the United States, exclusive of machines employed for experimental purposes: New Jersey Zinc Company, Franklin Furnace, N. Y., 20; Empire Zinc Company, Cañon City, Colo., 5; Colorado Zinc Company, Denver, Colo., 2; Resurrection Gold Mining Company, Leadville, Colo., 3; Summit Mining & Smelting Company, Kokomo, Colo., 2; Pride of the West Mining Milling Company, Washington, Ariz., 6; Warren Separating Company, Warren, N. H., 1; and Bully Hill Mining & Smelting Company, Winthrop, Cal., 1.

Numerous new forms of electro-magnetic separators have lately been invented. Alexander Dean and E. M. Oviat[16], of Denver, Colo., patented an electro-magnetic ore separator. Other magnetic separators were described by Myron Dings[17], of Milwaukee, Wis., and F. T. Snyder[18], of Oak Park, Ill. A new separator has also been designed by Robert McKnight. Two new Swedish separators, the Forsgren and the Ericsson, were described by Hecker[19]. The separator invented by Clarence O. Payne[20], which is used by the Bertha Mineral Company, at Delton, Va., was described in THE ENGINEERING AND MINING JOURNAL.[21]

Samuel W. Osgood[22] presented data showing that a mineral which is ordinarily susceptible to magnetism becomes less affected on being ground finer, that the ratio of extraction is not in proportion to the number of passes be-

16 United States Patents Nos. 751,100 and 751,150, both of Feb. 2, 1904.
17 United States Patent No. 755,282, March 22, 1904.
18 British Patent No. 28,399, of 1903.
19 *Glückauf*, 1904, p. 77.
20 United States Patents Nos. 762,751, 762,752 and 762,753, all of June 14, 1904.
21 June 23, 1904.
22 THE ENGINEERING AND MINING JOURNAL, Sept. 5, 1903.

fore the magnet, and that repeated passages of finely ground magnetic mineral will not eventually effect a complete extraction.

Metallurgy.

There have been numerous contributions in patent and technical literature during the past year to the subject of zinc metallurgy, most of which are herein summarized, the review extending up to the date June 30, 1904. Reference may also be made to the treatises 'Geschichte der Rohzinkfabrikation,' by Dr. Leopold von Wiese; 'Die Metalle,' by Dr. B. Neumann; 'Production and Properties of Zinc,' by W. R. Ingalls, and 'Metallurgy of Zinc and Cadmium,' by W. R. Ingalls. A paper on 'The Smelting of Zinc Ores,' with especial reference to the practice in Kansas, was read by A. J. Diescher[23] before the Engineers' Society of Western Pennsylvania.

PHYSICAL AND CHEMICAL PROPERTIES.

Reduction Temperature of Zinc and Cadmium Oxides.—The results of a study of the reduction temperature of zinc oxide were presented by Woolsey McA. Johnson.[24] He made the following observations with the aid of a specially designed experimental furnace and a LeChatelier pyrometer:

Material.	*Reducing Agent.*	*Temperature.*
Zinc oxide, chem. pure	1100° charcoal	1022°C.
" " c. p., calcined at 1300° C.	" "	1025°
" " chem. pure	Soft coke	1029°
" " c. p., calcined at 1100°	" "	1048°
" " c. p., calcined at 1300°	" "	1061°
" " c. p.,	Graphite	1084°
Roasted ore (Colorado)	Soft coke	1029°
" " (Joplin)	" "	1073°
" " "	600° charcoal, very soft	1033°
" " "	1100° "	1059°
" " (Colorado)	1500° "	1073°
Joplin ore	" "	1080°
" "	Graphite	1116°
Colorado ore	"	1120°
Zinc sulphide (Joplin)	Cast iron filings	1187°

The coke used in all the experiments was made in 48 hours in bee-hive ovens; it contained 87 per cent fixed carbon and 1 per cent volatile matter. The charcoal was made by heating Southern pine in a large, covered crucible until volatile matter ceased to evolve. The Joplin ore was roasted at about 1050° C.; the Colorado ore at 900 to 950° C.

23 *Proceedings*, March, 1904.
24 *Electrochemical Industry*, Vol. II, p. 185, May, 1904.

Mr. Johnson expresses the idea that the reduction of zinc oxide is caused by the very slight vapor of solid carbon and the slight dissociation pressure of zinc oxide tending to break up the zinc oxide into zinc and free oxygen. "It is easy to imagine the effect of heat in making a denser and more stable configuration of the atoms in the molecule on reducing these vapor pressures. . . . . . These results and conceptions tend to show that the primary reduction of zinc oxide by carbon is not caused by carbon monoxide, although there is no doubt that carbon monoxide does tend to increase the rate of reduction after the primary reduction is once started."

Determinations of the reduction temperature of cadmium oxide, chemically pure, made by wet method, gave 767° C. with 600° charcoal as the reducing agent, 813° C. with 1100° coke, and 849° C. with graphite turnings.

Boiling Points.—D. Berthelot[25] reported the following determinations of boiling points:

Cadmium .... $778° + \frac{H - 760}{9}$

Zinc. .... $918° + \frac{H - 760}{8}$

in which H = height of barometer in millimeters. The above figures are said to be accurate within 2°.

Specific Heat.—Dr. Ferd. Glaser[26] determined the specific heat of zinc (containing 1.29 per cent lead and 0.60 per cent iron) to be 0.099566 at 281.5° C.; 0.105707 at 355.8° C.; 0.099925 at 374° C.; and 0.18113 at 487.7° C. Pure zinc at 430° C. gave 0.175992.

Volatility of Gold in Presence of Zinc.—K. Friedrich[27] disputes the statements of Grünhut as to the volatility of gold in the presence of zinc, and shows by experiments that if gold is lost when zinc is distilled it can only be when the zinc is volatilized with extreme energy, and is then carried off mechanically as gold or zinc-gold alloy.

Atmospheric Action on Zinc.—G. T. Moody found that the scale formed on sheet zinc under atmospheric exposure corresponds approximately to the formula $ZnCO_3{,}3Zn(OH)_2$.

Condition of Zinc in Slags.—W. Maynard Hutchings[28] reported that his chemical and microscopical investigations led to the conclusion that in slags, which are not too basic, zinc oxide is combined as silicate. On one occasion slags were produced for several days in which crystals of willemite were abundant. The same slag contained a large amount of magnetite, with which a considerable proportion of zinc oxide was combined. Crystals of magnetite, separated from the slag and treated with strong acid, yielded shells of ma-

25 *Annales de Chimie* (7), XXVI, 58-144.
26 *Metallurgie*, I, vii, 122, Apr. 8, 1904.
27 *Zeitschrift f. angew. Chemie*, 1903, XVI, xii, 269-271.
28 The Engineering and Mining Journal, Dec. 24, 1903.

terial retaining the form of the original mineral, but very rich in zinc oxide (being, in fact, a zinc-iron spinel). Zinc-iron spinels have been observed in other slags.

Cadmium in Spelter.—The percentage of cadmium in the Western spelter that is made now especially for the brass trade has been the subject of considerable attention. The Western spelter is still made chiefly from Joplin ore, and that ore contains ordinarily a rather high percentage of cadmium, which has not been until recently thoroughly appreciated, possibly because of the imperfections of the ordinary technical methods of determining cadmium, to which Mr. W. George Waring[29] especially has recently called emphatic attention.

Mr. Waring reports the following analyses of Joplin blendes:

Ore.	*Zinc.*	*Iron.*	*Lead.*	*Copper.*	*Cadmium.*
Sphinx Mine, Neck City, Mo...	65.77	0.55	0.00	0.077	0.135
Average of 2,270 carloads from Webb City, Mo.............	57.08	2.60	0.90	0.050	0.337
Standard Mine, Fortuna, Mo...	61.97	0.55	0.815	0.133	0.436
Maude B. Mine, Webb City, Mo.	55.70	4.90	trace	trace	0.227
Big Six Mine, Aurora, Mo.....	56.75	1.88	none	0.004	0.018
McKinley Mine, Prosperity, Me..	57.20	1.25	5.29	none	0.550
Hudson Mine, Pleasant Valley Missouri	62.05	0.61	none	0.030	0.322
Big Circle Mine, Oronogo, Mo..	56.90	1.64	1.51	trace	0.110
Willard Mine, Mo............	63.30	0.80	0.41	0.064	0.320
Gundling & Standard, Fortuna, Missouri.	63.50	0.90	0.32	0.107	0.530
October Mine, Webb City, Mo...	58.10	2.74	0.59	none	0.460
Majestic Mine, Webb City, Mo..	57.05	1.82	1.61	none	0.330
Three Shaft, Carterville, Mo....	60.20	2.08	0.89	0.090	0.140
Uncle Sam Mine, Aurora, Mo...	61.20	0.75	none	0.010	0.590
Underwriters' Mine, Webb City, Missouri	57.95	1.60	1.62	none	0.710
Jack Rose Mine, Joplin, Mo....	54.70	1.36	1.02	none	0.260
Average of 2,145 shipments, Joplin District	57.75	2.32	1.07	0.042	0.388

It will be observed that the cadmium tenor in the major part of the samples is unusually high, Jensch in his investigation of this subject having found that the average of the Silesian ore was only about 0.1 per cent cadmium, while the richest sample examined (blende from Finland) contained only 0.46 per cent cadmium.

It has lately become the general practice among Kansas smelters to reserve

29 *Journal American Chemical Society*, XXVI., Jan., 1904.

the first draw of spelter for brass-making purposes, this being lower in lead than the entire run, because it is distilled at the lowest temperature. For the same reason it is higher in cadmium, a certain brand of "brass special" spelter showing, for example, Pb, 0.55 per cent, Cd, 0.29 per cent, Fe, 0.02 per cent, and Zn, 99.00 per cent, total 99.86 per cent. It has been suggested that the cadmium content of some of the "brass special" spelters may be objectionable in the manufacture of certain kinds of brass. An investigation of this subject is now in progress.

ROASTING FURNACES.

The most important event of the past year in connection with roasting furnaces was the decision of Judges Sanborn and Thayer of the Circuit Court of Appeals, in the case of the appeal of the Lanyon Zinc Company and others vs. Horace F. Brown and others, filed March 28, 1904. This defined very clearly what is, and what is not, an infringement of United States patent No. 471,264, granted to Horace F. Brown.

The first claim of Brown's patent is as follows: "In an ore-roasting furnace having means for stirring and advancing the ore, a supplemental chamber at the side of the main roasting chamber and cut off from said main chamber by a wall or partition, and carriers in said supplemental chambers connected with the stirrers but removed from the direct action of the heat, fumes and dust, substantially as herein described."

This claim was upheld, and the Ropp furnace declared to be an infringement thereof, in previous cases before the Circuit Court of Appeals, on the ground that the supplemental chamber was an essential feature of the Brown furnace, and the inventor did not limit himself as to its position; the tunnel under the hearth of the Ropp furnace was held to be such a supplemental chamber, performing all the functions claimed by Brown.

The Cappeau furnace, having under the hearth an open space, where the track is laid on which runs the carriage that operates the rabble arms, was not held to have a supplemental chamber within the fair intent and meaning of those words, as employed by Brown in his patent. Although Brown showed the way to protect the rabble-operating mechanism of such a furnace, and might have worded his claims so as to cover the modification described in the Cappeau patent, he failed to do so.

It is established, therefore, that any furnace of this type which has a supplemental *chamber* of any kind is an infringement of the Brown patent, but if the rabble arms project through a slot into an open space, which cannot be construed as a *chamber*, there is no infringement. This distinction will separate into two classes the various furnaces of this general type that are in use. This decision was the culmination of a long and expensive litigation. The history of the case is briefly as follows: About six years ago the Edgar Zinc Company and the Collinsville Zinc Company, which had acquired the rights to the Brown patents for use in blende roasting in certain States, brought suit against the Lanyon Zinc Company, which was using the Ropp furnace, on the ground that the latter was an infringement. A decision of the United States Circuit Court in 1899 was in favor of the plaintiff. The defendants carried the case up to the Court of Appeals and lost. The Ropp furnaces in use at Iola and Laharpe were then modified into what is called the Cappeau furnace, which the Brown people claimed to be still an infringement, and brought a new suit. They were again victorious in the lower courts, but lost on appeal.

Numerous new roasting furnaces have been recently described. The tendency of metallurgical practice at the present time is strongly in favor of the McDougall type, which embodies all the advantages of the multiple-hearth shelf burners with the maximum of strength in construction and great simplicity in the rabbling mechanism. These furnaces have now come into extensive use in acid making and the metallurgy of copper, and already to some extent in the metallurgy of zinc. The practice with them at Butte, Mont., was described by Prof. H. O. Hofman,[30] and that at Salt Lake City, Utah, by S. S. Sorensen.[31]

McDougall Type.—The McDougall furnace was invented and used in Great Britain during the 70's, but for a long time its use did not extend. Recently, however, it has come into very large use in the modified forms invented by Herreshoff, Klepetko & Evans, O'Brien, Trent and others. These furnaces conform essentially to the principles of the original McDougall furnace, embodying nothing more than what pertains to structural details, although in some cases the dimensions have been greatly increased. The original patents on the McDougall furnace having long since expired, the principles are free to anyone, and the patents on the improved modern furnaces are necessarily narrow, relating to such details as the form of the stirring arm, method of cooling the stirring arms, etc. These improvements have been, however, of great practical importance and have led to the development of what is perhaps the most efficient roasting furnace for many purposes that we now have.

Subsequent to the date of the original McDougall furnaces the Ross & Welter and Haas furnaces, which are of the same type, came into use in Europe for blende roasting, and of these the Haas is still employed. Most attention to this type of furnace was attracted, however, after the invention of the Herreshoff form.

The Herreshoff furnace, which was first employed for burning pyrites fines for sulphuric acid manufacture, was described in THE MINERAL INDUSTRY, Vol. VI, page 236. In its latest construction it consists of a cylindrical shell of ¼-in. steel, 11 ft. 7 in. in diameter, lined with 8 in. of red brick. The horizontal bottom of the cylinder and four arches of fire brick,

30 *Transactions* Am. Inst. Min. Eng., Feb., 1903.
31 *Journal* Canadian Mining Institute, Vol. VI, pp. 306-312.

4.5 in. thick, constitute the roasting hearths. Passing through the latter there is a central vertical shaft, driven from below, which carries the stirring arms, two per hearth. The shaft is hollow, 14 in. in diameter. Above each hearth there is a slot, 4 in. wide and 5 in. high, which passes through the shaft; these are to receive the ends of the stirring arms. The latter are held by a self-locking joint, their own weight, 120 lb., holding them in position. To remove an arm, it is lifted about 3 in. at the outer end, when it can be pulled out. The operation is so simple that an arm can be removed and a new one substituted in about one minute. This was one of the great improvements in the design of this furnace.

The operation of the Herreshoff furnace is very simple. The ore is fed mechanically from a hopper to the uppermost hearth by means of a piston working in a horizontal cylinder; the piston makes two strokes per minute. The ore dropped near the center of the first hearth is pushed out to the periphery of the latter, where it drops through holes to the next hearth below. It is then worked toward the center of the second hearth, where it drops through a hole around the revolving shaft to the third hearth, and so on. The plows of the stirring arms are set so as to effect the proper movement. The area of the openings in the hearths is sufficient to permit free passage of the sulphurous gas, which travels in the opposite direction to the ore. The ore is finally discharged through a 5x3 in. outlet at the circumference of the lowest hearth.

The central shaft makes one revolution in two minutes. In passing through those hearths whereof the holes are at the periphery, the joint is sealed by the ore itself in a simple trap. The shaft is cooled by drawing air through it, for which purpose a 30-ft. chimney is placed above it. The stirring arms, rectangular in cross-section, are also hollow. That portion of them in which the greatest strength is required, as well as the vertical shaft, are kept below red heat. The upper surface of the arched hearths is not built up horizontal, but is leveled with sand, ashes, or ore itself.

One of the first strictly metallurgical employments of the Herreshoff furnace was at the works of the Montana Ore Purchasing Company, at Butte, Montana, where two furnaces of five hearths, each 9 ft. in diameter, were installed in 1894. Their success in burning the sulphide ore of Butte was such that more were added to this plant, until a total of 70 was in use. Furnaces of the same construction were also installed at other works at Butte. Most of the Herreshoff furnaces now in use at Butte are built with a shell of 0.25 steel, 11 ft. 6 in. in height and 10 ft. 10 in. in diameter. They are lined with one course of red brick, giving a diameter of 9 ft. 6 in. inside of the lining. A few furnaces in the district are built with walls of the thickness of two brick, *i. e.*, 16 inches, and instead of being encased with steel plate are simply hooped with steel bands. These furnaces are said to do better work than those which are constructed with a steel shell lined with a single course of brick, this confirming experience that has been gained elsewhere to the effect that in a roasting furnace the conservation of heat by means of thick brick walls is important; moreover, when the masonry of a furnace is cased with iron, the radiation of heat from the outer surface is greater than in the case of an unsheathed brick surface.

The Herreshoff furnaces now in use at Butte have hearths of fire brick, 4.5 in. in thickness, 12 to 13 in. apart. The rise of the arch is 4.5 inches. The central revolving shaft, 14 in. in diameter, which is cooled by a current of air passing through it, carries two stirring arms for each hearth, these arms having 7 and 8 teeth respectively. A furnace of which the shaft is run at 50 r. p. h. roasts in 24 hours from 5 to 6 tons of wet concentrates, containing about 35 per cent sulphur, the sulphur being reduced to 6 per cent in the burned ore. The hearth efficiency is therefore about 30 lb. per sq. ft. per 25 hours. The quantity of flue dust made is rather large.

The O'Brien furnace is quite similar to the Herreshoff, and, like the latter, has been used very successfully in burning pyrites. The chief differences are in the central vertical shaft and the stirring arms. The former is made tapering, being largest at the upper end, and is mounted at the lower end upon ball bearings. The tapering form of the shaft permits it to be easily lifted out of the furnace, the stirring arms being of course detached. Both the central shaft and the stirring arms are arranged for air-cooling. The central shaft is open at the top and the sulphur gases are taken off through a ring of apertures in the top of the furnace around it. The ore is fed by means of a screw, which is connected directly with the main driving shaft by means of an eccentric and pawl lever, the feed being adjustable without having to go to the top of the furnace.

The Klepetko & Evans furnace was a direct development of the Herreshoff, the chief initial difference being an increase in size, the new furnace being 16 ft. in diameter and having 8 hearths. The increase in diameter led to structural difficulties, especially in connection with the arms, the increased length of which caused them to bend under their own weight when subjected to the high temperature of the furnace, in spite of the circulation of air through them. This difficulty was obviated by cooling the arms by circulating water through them. Also, the number of hearths was reduced from eight to six.

As now used at Butte the Klepetko & Evans furnace is a shell of 3/8 in. steel, lined with one course of fire brick, the furnace being 18 ft. 3.5 in. in height and 15 ft. 10 in. in diameter. It has 6 hearths, each rising 9 in. The vertical distance from hearth to hearth is 3 ft. For each hearth there are two stirring arms, which are revolved 1 r. p. m. The furnace stands on columns 12 ft. high, in order to allow the burned ore to discharge into hoppers, whence it can be drawn by gravity into cars. Six or eight furnaces are grouped in a battery in which the single furnaces are placed 18 ft. apart, center to center in one direction and 21 ft. 3 in. in the other. Each furnace has two gas outlet flues, which are 2 ft. in diameter.

The vertical shaft of the furnace is driven from below, three or four furnaces being connected by friction clutches with the main shaft. There are six platforms surrounding the furnace, to give access thereto, and the clutches are so arranged that they can be thrown in or out from any one of the platforms. The water for cooling the vertical shaft and the stirring arms is introduced into the vertical shaft, which is 9 in. in diameter, through a 3-in. pipe near the bottom. One inch branch pipes extend out to the ends of the stirring arms. From the top of the shaft the water is discharged through two spouts into a stationary launder. When the furnace is run so that the overflow water is discharged at a temperature of 80° C., 20 gal. per minute are required by each furnace. The vertical shaft and the stirring arms are constructed of flanged sections so as to permit easy exchange of parts. The power required by a battery of these furnaces is 10 h. p.

The ore is fed into the furnace through feed hoppers, of which there are two, each of capacity for 33 tons of ore, suspended over each furnace. The great weight of the ore in these charge hoppers is said to prevent any hanging of moist fine ore, thus obviating a difficulty which is sometimes experienced. From the hoppers the ore is fed into the furnace by means of a suitable device operated from the vertical shaft of the furnace with which it is geared.

The tops of the stirring arms in the topmost roasting hearth are protected by cast iron caps against rapid wear from the ore coming down through the feed openings. The outer portion of each hearth is 9 in. thick, the inner 6 in. brick being saved by this construction, and the weight at the center of the arch being also reduced, while, moreover, possible contact between the hearth and stirring teeth when the hearth rises upon heating is obviated. The hearths are levelled off with a bed of crushed limestone, or of flue dust, or some other suitable material.

The stirring arms for each hearth have respectively seven and eight cast iron teeth, which are 8 in. long, 6 in. wide and ⅝ in. thick; the lower 3 in. of the teeth, which come in contact with the ore are chilled. It has been found that there is no advantage in making the teeth thicker than ⅝ in., since they wear off obliquely to the working surface and consequently would offer a larger wearing surface without having any longer life. As the teeth are worn out the ore builds up on the hearth. When the teeth are removed for renewal, a plow is slipped over the stirring arm and moved a little toward the center after every circuit whereby the crust on the hearth is easily and surely broken up. It has been found that the crust on the second hearth is harder to break than on the other hearths. The teeth on the topmost hearth last 25 to 34 days; those on the sixth last from six to eight months.

The gases escape from the furnace at temperature of 315° C., the furnace being operated under draught of 0.3 in. of water. Roasting begins on the second or third hearth, varying according to the strength of the draught and the revolutions of the stirring arms. With a strong draught the heat creeps up. When the stirring arms are revolved once in 55 seconds, the roasting begins on the second hearth. At one revolution in 75 seconds, it begins on the third hearth. Normally the three doors on the lower hearth are left open for the admission of air. If the furnace becomes too hot, the doors on the third hearth are opened sufficiently to check the draught. As the ore drops from hearth to hearth, the dust formed is carried upward by the gas current and striking the roof adheres thereto and builds. In order to protect the stirring arms from being worn out at those places they are protected by cast iron caps. When the dust accretion has attained a thickness of 4 inches it is barred off.

In starting a furnace crushed limestone is first fed in to form the working bottom. Then a small fire of dry, long flaming wood is started from the three side doors of the third and fifth hearths. A new furnace is brought to a dark red in three to four days. An old furnace requires only two days. When the furnace has attained the proper temperature, the feeding of ore is begun. After charging for five or six hours, it sometimes happens that the furnace cools down too much; it is then necessary to start a new fire for 1.5 to 2 hours on the third and fifth hearths; occasionally feeding of the ore is stopped and 0.5 ton of coal is charged, which is allowed to burn out by stopping the machinery, when it has come to the third hearth. The furnace does its best work with a draught corresponding to 0.3 in. of water; with less draught, the furnace gets cool. Normally the ore is about one and a half hours in passing through the furnace. Each furnace treats an average per 24 hours of 40 tons of ore containing 35 per cent sulphur, the sulphur content of the calcined ore being about 7 per cent. This corresponds to a hearth efficiency of 84 lb. per square foot per 24 hours. The performance of the furnace can be varied, of course, by altering the speed of the stirring arms. By running the latter at one revolution in 50 seconds the capacity is increased to 50 to 55 tons; by running at one in 75 seconds, it is reduced to 30 tons. A battery of six or eight furnaces is attended by 1-3 foreman, 1 furnace man, 1 helper, 1-6 oiler, 1-9 repair man and 1 trimmer per 8 hours.

The Klepetko & Evans furnace is in use at the Anaconda works, where there are 56 of them, at the Boston & Montana works at Great Falls, where there are 18; and at the Highland Boy works at Salt Lake City, where there are 8. According to Prof. Hofman, from whose paper (previously referred to) these data are taken, the cost of roasting in the Klepetko & Evans furnace at Butte is 35c. per ton, against 50c. per ton in the Herreshoff furnaces; both of these figures are very much lower than what is attained with any other of the mechanical roasting furnaces in use at Butte.

At the Highland Boy smeltery, near Salt Lake City, the furnaces, 16 ft. in diameter outside (14 ft. 6 in. inside), with six hearths, roast each about 35 to 40 tons of ore from 35 per cent sulphur down to 6 to 9 per cent in 24 hours, with no consumption of carbonaceous fuel. The ore is 2.5 to 3 hours in passing through the furnace, the rabbles making 1 r. p. m. (maximum speed 44 ft. per minutes). The power required is less than 1.5 h. p. per furnace. Two furnace-men with two helpers per shift attend to eight furnaces. The average cost of roasting in 1902 was 34c. per ton, including labor, power, supplies, repairs, tramming raw ore and calcines, and proportion of general expense, the actual operating expense exclusive of repairs and general charges being about 23c. per ton. The heat carried off by the cooling water corresponds to consumption of about 2,400 lb. of good coal per 24 h.

Further modifications of the McDougall furnace have been described in the recent patent literature.

Frank Klepetko, of New York, aims to increase the efficiency of the McDougall furnace by increasing the number of stirring arms in each hearth chamber.[32] If the blades on a single pair of arms be set in opposite directions, they will neutralize each other as to shoving the ore in or out, and will simply stir the ore. If, in a hearth having one pair of neutralizing arms, there be placed a third arm having blades disposed at a suitable angle to the radial axis of such arm, it will serve to feed the ore radially, but only as fast as did the first pair of arms before being neutralized by the reversed disposition of their respective blades; but, while the time of radial discharge will thereby be increased 50 per cent, the stirring action will likewise be increased 50 per cent, since there is the action of three arms instead of that of the original two. If the number of arms be increased to five, letting two pairs neutralize each other (thus getting the radial discharge of one arm only), the roasting time will be doubled while the stirring action will be increased 150 per cent. A similar effect would result from a still further increase in the number of arms, though it might not be practical on account of concentration of iron work at the center, or hub, of the cluster of arms. If it be not desired to increase the time of roasting, but simply to increase the stirring action, this can be effected by putting in four arms to a hearth and letting one pair neutralize each other, the two remaining arms operating to discharge the ore. In this case the time would remain the same, as there would be only two arms effective for the radial discharge or feed of the ore, but the stirring action would be doubled. Klepetko prefers, however, an odd number of arms, as three, since then not only the roasting time, but also the stirring action, is increased.

John B. F. Herreshoff[33] seeks to reduce the percentage of dust carried away by arranging special spouts in the hearths, so that the ore will be delivered from one hearth to the next one below without having to fall through the openings in which the ascending current of gas is passing.

Perhaps the most serious practical difficulty with the McDougall type of furnace is its tendency to produce a very large percentage of flue-dust. The

32 United States Patent No. 744,359, November 17, 1903.
33 United States Patent No. 729,170, May 26, 1903.

area of each hearth is comparatively small, and the small quantity of ore that is burned in a single furnace is subjected, by the successive drop from hearth to hearth, there being usually five or six hearths, to the strong current of gas going in the opposite direction, which carries off a great deal of dust. The showering of the ore from hearth to hearth is, however, probably an important factor in the roasting efficiency of these furnaces, and it is questionable if it be not better on the whole to put up with the dust and the trouble of re-working it rather than to alter this feature of the furnace.

Charles H. Repath and Frank E. Marcy,[34] of Anaconda, Montana, aim to reduce the dusting by arranging external flues, so that the gas current passes from one hearth to the next above through an elbow exterior to the main cylinder of the furnace, while the ore falls from one hearth to the next below through openings in the usual manner.

August R. Meyer,[35] of Kansas City, Mo., patented a muffle form of the McDougall furnace in which modifications are made in the construction of the central shaft and the means for holding the stirring arms in place.

Ernst A. Sjöstedt described at the Toronto meeting of the Canadian Mining Institute, March, 1904, a muffled McDougall furnace, used successfully for burning pyrrhotite at Sault Ste. Marie, Ontario.

Franz Meyer,[36] of New York, patented a muffle furnace, which consists of a series of McDougall furnaces—for example, eight, erected in a block of two rows of four each. The lowest and next to the lowest hearths are muffled, the flame flues extending through the length of the block. At one end of the block there are two fire-places, one for each side, from which the products of combustion pass through the flues under the lowest hearths of four furnaces and return through flues above the lowest hearths, thence passing to the chimney.

Long-hearth Furnaces.—A combination of the McDougall type of stirring mechanism with the long reverberatory hearth is made in several designs of furnaces, among which the Edwards and the Merton are finding successful and extensive application, especially in Australia. These furnaces have a series of revolving stirrers, the sweep of which occurs in over-lapping circles, so that the ore pushed forward by one arm is carried further forward by the next and so on. The Edwards furnace[37] was described in The Engineering and Mining Journal.[38] Edwards' furnace has a single hearth. That of Thomas D. Merton[39] has three superimposed hearths. A similar furnace, arranged with muffles, has been patented by F. J. Falding.[40]

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34 United States Patent No. 740,589, October 6, 1903.
35 United States Patent No. 750,877, February 2, 1904.
36 United States Patent No. 731,114, June 16, 1903.
37 United States Patent No. 714,464, Nov. 25, 1902.
38 Dec. 10, 1903, and Feb. 11, 1904.
39 United States Patent No. 697,863, Apr. 15, 1902, and The Engineering and Mining Journal, Dec. 10, 1903.
40 United States Patent No. 756,485, Apr. 5, 1904; also see Ingalls, 'Metallurgy of Zinc,' p. 141.

Alfred Diescher,[41] of Pittsburg, Pa., has patented a modification of the Ropp furnace, in which the rabbles are carried on rails at each side of the hearth, as in the Brown straight-line furnace. Two pairs of rack bars are arranged parallel with and adjacent to the rails. These bars are given a reciprocating movement by a suitable mechanism, whereby the rabbles are caused to move forward. Upon emerging at the discharge end of the furnace the rabble is gripped to a cable going around the furnace substantially as in the Ropp, whereby it is transferred to the feed end, preparatory to making another passage through the furnace. The cable for transfer of the rabbles passes through a tunnel under the hearth, but there is no slot in the latter, the design of the furnace being obviously to avoid that feature.

In another patent Diescher[42] shows a furnace similar to the one above described, in which the rabbles are drawn by a cable extending around the furnace, as in the Ropp furnace, but inside of the furnace the rope is carried on idlers in a slot about at the hearth level. A rather complicated mechanism is required to bring the rabbles around the sharp curves at each end of the furnace, inasmuch as they are supported by wheels at each end, instead of the simple central support of the Ropp furnace.

S. D. Craig, G. E. Kelly and W. Turner,[43] of Laharpe, Kan., patented a mechanical reverberatory furnace with a long, sloping hearth, and a rabbling carriage operated back and forth over the hearth by means of a wire cable and suitable reciprocating mechanism, the rabbles being automatically adjusted so as to stir the ore, but not advance it on the return movement.

Elihu Swain and Dr. Clark Wood,[44] of Iola, Kan., patented a mechanical furnace of the O'Hara type.

DISTILLATION AND DISTILLATION FURNACES.

Methods.—In methods of distillation, the chief progress is in better understanding of the details, among others, the necessity of insuring a thorough mixture of the ore with reduction material and the extent of the reducing action of iron upon zinc sulphide. In arguing the latter point, H. Brandhorst declares that it is unnecessary to carry the desulphurization of blende so far as is commonly done.[45] Johnson, in experiments previously referred to, has shown that whereas roasted Joplin ore is reduced by carbon at 1029° to 1073° C., the raw ore is reduced by iron at 1187° C. Reference may also be made to the experiments of Prof. Prost.[46] Some practical experiments upon the reduction of raw blende made at a European works in 1903 are privately reported to have been of considerable promise.

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41 United States Patent No. 740,102, Sept. 29, 1903.
42 United States Patent No. 740,103, Sept. 29, 1903.
43 United States Patent No. 754,199, March 8, 1904.
44 United States Patent No. 734,104, July 21, 1903.
45 *Zeitschrift f. angew. Chemie*, XVII, xvi, 505, April 15, 1904.
46 *Bull.* Assoc. Belges des Chimistes, X, vi, 246-263; Ingalls, 'Metallurgy of Zinc,' p. 207.

F. Cochlovius[47] refers to the increasing proportion of roasted blende that the Silesian smelters are having to treat and the tendency to adopt the Rhenish furnace with its comparatively small retorts to distil the richer ore; and argues that the large muffles of the existing furnaces can be used successfully for treating the same ore by altering the method of operation, charging them in pairs one after the other, and resuming the distillation immediately, instead of performing the manœuver as at present. In the proposed way the period of distillation for the charge in each pair of retorts will be extended and an increased extraction of metal will be obtained.

J. R. Down,[48] of Swansea, Wales, proposes to distil zinc ore in the form of briquettes molded to fit the retort, using 0.5 to 2 per cent of sago flour as binding agent. The ground mixture of ore and coal is steamed in the pug-mill to render the sago plastic and binding.

Edward H. Miller,[49] of London, England, patented the process of distilling raw zinc-lead sulphide ore by admixture with silica and pitch, together with lime (according to the silver value of the ore), making into briquettes and heating in retorts. The finely crushed ore is mixed with 66 2-3 to 100 per cent silica-sand, by volume, and 5 to 20 per cent hard pitch, by weight. If fairly rich in silver, some lime paste is added. The mixture is formed into suitable briquettes, which are dried at 30° to 60° C. When charged into the retort, each layer is sprinkled with slaked lime and some coarse lumps of quick-lime are put on the top.

In an experiment with ore from Broken Hill, assaying Pb, 17.27 per cent; Zn, 15.54 per cent; Mn, 7.2 per cent; Fe, 7.86 per cent; Al_2O_3, 1 per cent; S, 12.30 per cent; SiO_2, 33.45 per cent; O, etc., 5.38 per cent; 0.05 oz. gold, and 14.75 oz. silver per 2240 lb.; to 100 lb. of ore there was added 20 lb. of sand, 5 lb. of pitch and 1 lb. of lime. Charged into a retort, the latter was gradually raised to white heat. After 30 minutes, zinc began to distil off and continued for two hours, when the distillation ceased. The briquettes were in excellent condition for further smelting, being fairly hard and tough. They assayed 1.12 per cent Zn and had lost one-third their weight. The extraction of zinc was 90 per cent.

Fritz Projahn,[50] of Stolberg, Germany, described a method for reducing low grade and ferruginous zinc ores by burning off the sulphur in an ordinary kiln and passing over the roasted ore an excess of pre-heated illuminating gas, first at a temperature only sufficient to reduce the iron oxide and later at a temperature sufficient to reduce the zinc oxide. In this way the oxidizing action of the aqueous vapor and carbon dioxide, originating from the reduction of the iron oxide, upon the metallic zinc is avoided.

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47 *Zeitschrift* des Oberschles. Berg- u. Huttenm.Vereins, March, 1904; *Metallurgie*, I, x, 204.
48 British Patent No. 14,982, July 5, 1902.
49 United States Patent No. 751,401, Feb. 2, 1904.
50 German Patent No. 142,231, Nov. 4, 1900.

William C. Wetherill,[51] of Cañon City, Colo., patented the process of roasting and distilling mixed sulphide ores containing gold and silver, crushing and screening the residuum and passing the latter over suitable magnetic separators, e. g., the Wetherill. This process is based on the discovery that by compounding the furnace charge so that it will contain a certain minimum proportion of iron, the precious metals will associate with the iron, the particles of which being magnetic are capable of removal from the residuum. The proportion of iron in the charge must not exceed what the retorts are capable of withstanding and in general should not exceed 13 per cent by weight of the calcined ore.

C. W. Sexton,[52] of Brooklyn, patented a process of substantially the same nature as that described by Wetherill.

Oliver H. Picher,[53] of Joplin, Mo., patented the process of treating ore containing the sulphides of lead and zinc by smelting in a Scotch hearth furnace at temperature sufficient to sublime the lead without volatilizing any important quantity of zinc. The residue is then treated as a zinc ore by roasting and distillation in the ordinary manner. The lead is recovered as a fume consisting of sulphide, sulphate and more or less oxide. The sublimation can be effccted energetically at a temperature below that at which the zinc is volatile. The inventor states that his process has been successfully applied to ore containing from 1 per cent to 10 per cent lead.

Carl V. Petraeus [54] in a series of patents describes a process for the treatment of zinc ore, which consists substantially in smelting the residues from ordinary distillation on Wetherill hearths, collecting the zinc fume, and making a cinder which is suitable for smelting for recovery of the precious metals. The fume may be reduced to spelter by distillation in retorts, its density being much increased by a preliminary heating to 1200° to 1400° F. This chain of processcs was the subject of experiment by the Lanyon Zinc Company, without, howevere, leading to a successful commercial result.

Furnaces.—In Europe, the tendency in Belgium and Rhineland appears to be toward the Sicmens-Rhenish furnaces, such as are used at Engis, Overpelt and Prayon. Similar furnaces are being erected at new works in Upper Silesia. The United States Zinc Company, in its plant at Pueblo, Colo., practically duplicated the furnaces at Overpelt. These furnaces are expensive to build, but are economical of fuel and afford the adequate and even temperature that effects a good extraction of metal. The Ferraris furnace, used at Monteponi, Sardinia, continues to give satisfactory results, its efficiency having been increased by some minor modifications. The following determina-

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51 United States Patent No. 724,637, Apr. 7, 1903.
52 British Patent No. 7,693, Apr. 2, 1903.
53 United States Patent No. 735,903, Aug. 11, 1903.
54 United States Patents Nos. 735,902, 736,008, 736,009, and 736,010, all of Aug. 11, 1903.

tions were made of the temperature attained in the Ferraris furnace in the ordinary distillation at Monteponi:

7 A.M.	a1200°C.	2.30 P.M.	1200°C.	11 P.M.	1350°C.
8	b1150	3.30	1200	12 M.	1400
9	c1100	4.30	1200	1. A.M.	1400
10	d1050	6.00	1200	2.	1350
11	1050	7.30	1300	3.	1300
12 A.M.	1150	9.	1300	5.	1250
1.30 P.M	1200	10.	1300	6.	1200

a Beginning of the maneuver.
b Change of retorts.
c Beginning of charging.
d Beginning of the distillation.

A. W. Schrubko[55] describes the furnaces and methods employed at Dombrowa, Poland. The practice is substantially the same as in Upper Silesia.

O. Mühlhäuser[56] states that the fire brick for zinc furnaces made from St. Louis clay are of approximately 2 sp. gr. and 25 per cent porosity. Their infusibility, toughness and comparatively slight shrinkage under long continued heating makes them well adapted to their purpose, but to insure the best results they should be burned at a temperature fully 100° C. above the maximum to be experienced in the furnace. A brick under fire 75 months showed 2.2 sp. gr. and 15.5 per cent porosity, thus indicating the shrinkage.

Among the natural gas smelters of Kansas there has been no important alteration in the furnace design, though new forms of furnaces have been experimented with in the effort to obtain a more equable temperature and an easier maneuver. In the United States the natural gas smelting interest is predominant. Iola remains the chief center, and although new concerns manifest a tendency to locate elsewhere, because of the preemption of the best gas territory in the Iola pool, they stick to the Iola type of furnace. The latter is undergoing some changes; although the type is well settled upon, minor modifications are made according to individual ideas. Some smelters have increased the length of the furnace to 18 sections, giving 720 retorts per block, while others have reduced the length by constructing 'split furnaces,' which are an ordinary block cut transversely into two, both in one house, but each with its own pair of chimneys, so that it is practically an independent furnace. There has been manifest lately a tendency to cut down the height of the furnaces from five rows to four rows, a modification which is much liked by the men, since the four row furnace is considerably easier to charge. In the minor details of the pipe fitting, and the arrangement of the ports for the introduction of the air and gas, almost every smelter has his own ideas, and no two will have precisely the same method, although the general system is the same.

The Convers & Desaulles furnace, used by the New Jersey Zinc Company, at its Eastern works, has been tried at one of the works of the Prime Western Spelter Company, modified to permit the use of natural gas.

55 *Gornij Journal*, 1903, LXXIX, 324-366; abstract in *Metallurgie*, I, viii, 151-156, and I, ix, 178-18.
56 *Zeitschrift f. angew. Chemie*, XVI, xiv, 321-323.

Among the recent patents are the following:

Joseph P. Cappeau[57] patented the design of a distillation furnace in which the air for combustion of the gas is introduced through hollow buckstaves, as in the standard Iola furnace, but the latter communicate with a canal under the hearth of the furnace (instead of with an air main overhead) which in a way affords means for pre-heating the air to some extent. The drawings show a single-front furnace, operated by natural draught.

Philip A. McKay, of Wenona, Ill., and William E. Moore,[58] of Peru, Ill., patented a regenerative furnace in which there are two pairs of checkerworks, one pair situated above the other. The upper pair comes in between the combustion chambers in which the retorts are placed. This form of construction necessitates a very wide structure.

Oscar H. Eliel,[59] of Lasalle, Ill., patented a furnace with vertical retorts and mechanical means for charging and discharging.

Paul Schmieder,[60] of Lipine, Germany, patented a furnace which is a combination of retort and blast furnace. There is a vertical, cylindrical retort, charged from the top and heated externally, which extends through and below the combustion chamber, terminating in a crucible. Connecting with the upper part of the shaft there are three condensers, at different levels, which pass through the combustion chamber. The charge in descending is distilled in the ordinary manner. The residue sinking to the lower part of the shaft, which is not heated externally, is smelted by an air blast introduced through tuyères just above the crucible. The slag is tapped from the crucible and the zinc oxide driven off is conducted away through suitable openings above the crucible.

Evan H. Hopkins,[61] of London, England, patented a condenser (for attachment to any form of retort), in which one portion is packed with coke, which of course becomes heated during the distillation. The zinc condensed in the coke trickles down into a receptacle formed in the lower side of the condenser. The form of condenser shown is impracticable, but the claims of the patent are quite broad.[62]

Thomas Jones,[63] of Iola, Kan., patented an apparatus for charging retorts, which comprises a holder for the charge and means (e.g., a mechanism operated by compressed air) for forcing the charge from the holder into the retort. The charge is preferably agglomerated by the addition of a small amount of coal tar. In another patent, Jones describes an apparatus for

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57 United States Patent No. 720,664, Feb. 17, 1903.
58 United States Patent No, 750.868, Feb, 2. 1904.
59 United States Patent No. 742,406, Oct. 27, 1903.
60 United States Patent No. 757,059, Apr. 12, 1904.
61 United States Patent 731,184, June 16, 1903.
62 See also United States Patent 701,885, June 10, 1902, Hopkins.
63 United States Patent 742,196, October 27, 1903.

blowing the residues out of retorts, the essential feature of which is a peculiar wedge-shaped head.[64]

J. J. Turner and J. A. Dowler,[65] of Laharpe, Kan., patented a machine for molding Belgium condensers, which consists substantially of a series of molds carried by a revolving table and a plunger arranged to operate successively in the molds.

Thomas J. Carlton,[66] of Iola, Kan., patented the composition for coating and protecting the walls of retorts, which is made up of the following ingredients: 25 lb. graphite, 10 lb. burned fire clay, 1 lb. potassium nitrate, 25 oz. "cobalt," thoroughly mixed with 15 gal. water and applied about 4 hours before putting the retort into the tempering furnace.

Electric Furnaces.—Considerable attention is being devoted to the design of electric furnaces for zinc smelting, which should not present any great difficulty, and may offer some important advantages. The prime question is whether those advantages will compensate for the large losses of power in transforming the energy of coal into mechanical power, then into electrical power, and finally into heat. The efficiency of even gas-engines, which is considerably higher than that of the most perfect steam plant, is still so low that it does not appear that so high a degree of economy can be obtained from the coal as in its direct use by gasification and combustion in regenerative furnaces. With cheap water-power the conditions may be different. According to private information, De Laval is producing considerable zinc by electrical smelting in Norway with more or less successful results from the technical standpoint.

Salguès describes experiments on the electric smelting of zinc ore at a carbide works at Crampagna, Ariège, France.[67] In a 100 kw. furnace, smelting ore containing 40 per cent Zn, approximately 5 kg. spelter was obtained per kilowatt-day. It is expected to attain a yield of 2,000 kg. spelter per kilowatt-year. With pre-heated ore, the production might possibly be doubled. An output of 90 per cent of the zinc in the ore can be obtained. Raw blende can be smelted.

Oliver W. Brown, of Bloomington, Ind., and William F. Oesterle,[68] of Marion, Ind., patented the process of smelting in an electric furnace a mixture of blende, carbon and lime, simultaneously producing spelter (distilled off and condensed in the usual manner), calcium carbide and calcium bisulphide.

Smelting in the Blast Furnace.—A plant for the application of the Lungwitz process of smelting in the blast furnace under high pressure[69] is being erected at Warren, N. H., where the old zinc-lead mine has been reopened.

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64 United States Patent 742,187, October 27, 1903.
65 United States Patent 752,484, February 16, 1904.
66 United States Patent 732,707, July 7, 1903.
67 *Rev. prat. de l'Electricite*, 1903, XII, 313.
68 United States Patent 742,830, November 3, 1903.
69 United States Patents 538,785, May 7, 1895, and 555,961, March 10, 1896.

HYDROMETALLURGICAL AND ELECTROMETALLURGICAL PROCESSES.

Some experimental work on a large scale has been done during the past year on new processes for the treatment of mixed ores, but none has yet been advanced to the commercial stage. Among others, experiments have been made with the Ashcroft & Swinburne process, with the Havemann process at Angoulême, France, and with the Ellershausen process at Hafna, Wales. At Denver, Colo., experiments have been made with the Dewey process, which has not yet been publicly described. The Ketchum process is being tried in Maine.

Prof. Borchers refers to the incomplete solubility of the zinc in roasted ferruginous ore in any ordinary reagents; an extraction of about 80 per cent being the maximum possible, and attribues this to the formation of zinc ferrate during the roasting.[70] This is confirmatory of the opinions previously expressed by the present writer as the result of numerous experiments in the roasting and leaching of such ores. Similar results have been noted by other experimenters. During the past year, certain experiments in the laboratory by two independent investigators, of which the present writer has been privately informed, have demonstrated the formation under certain conditions of zinc ferrate, which heretofore has been an almost unknown compound.

V. Bermont,[71] of Paris, patented the process of leaching oxidized ore with ammonia, or solution of an ammonium salt, precipitating metals other than zinc by means of sodium sulphide, filtering, and throwing down the zinc by evaporating off the ammonia.

Karl Danziger,[72] of Zawodzie, Germany, patented the process of spreading pyritous ore on floors heated by waste fire-gases, and subjecting to the action of moist air, oxidizing the sulphide of iron to sulphate, which can be separated from the blende by lixiviation, the blende remaining unaltered.

F. Ellershausen and R. W. Western have been exploiting a new process, which was described by Edward Walker in THE ENGINEERING AND MINING JOURNAL of March 14, 1903. The ore is roasted to sulphate and oxide, treated with a 5 per cent solution of acid ammonium sulphate, which takes the zinc into solution as double sulphate of zinc and ammonium, the zinc being then precipitated as hydroxide by addition of ammonia, filter-pressed, calcined and retorted. Some of the ammonium sulphate solution is treated with sulphuric acid to reproduce the acid sulphate, while the remainder is re-treated with lime to regenerate the ammonia required for a subsequent precipitation. If it be desired to make a pure oxide, any iron that may have gone into solution is oxidized by the addition of bleaching powder, or by aeration, and precipitated by lime.

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70 *Metallurgie*, I, vii, 113, April 8, 1904.

71 British Patent 6,752, March 19, 1902; French Patent 315,888, 1901; United States Patent 751,712, February 9, 1904.

72 United States Patent 754,643, March 15, 1904.

Walker's statements were criticized by Gilbert Rigg,[73] who expressed the opinion that acid ammonium sulphate has no advantage as a lixiviant over sulphuric acid, while it has serious disadvantages, the chief of which is the inability to precipitate zinc as hydroxide completely in the presence of normal ammonium sulphate, at least 5 per cent of the zinc remaining in solution. Therefore, when the ammonium sulphate solution be treated with lime for reproduction of the ammonia, this zinc will be thrown down with the lime precipitate and will be lost. Moreover, ammonia precipitates from a solution of zinc sulphate not merely zinc hydroxide, but rather a basic sulphate, corresponding to the formula $Zn(OH)_2$, $ZnSO_4$. The insolubility of a considerable proportion of the zinc in the roasted ore is also pointed out.

Walker in a subsequent communication[74] disputed Riggs' statement as to the precipitation of a basic sulphate, reporting that the average product obtained by Ellershausen and Western contains 98 per cent ZnO. (This can hardly refer to the fresh precipitate. If it refers to the calcined product, it can easily be understood that zinc sulphate precipitated may have been decomposed during the calcination. Recent pyrometric investigations have shown that zinc sulphate is decomposed at much lower temperature than used to be thought.) Rigg in THE ENGINEERING AND MINING JOURNAL, July 25, 1903, reiterated his assertion as to the precipitation of a basic sulphate, stating that he has invariably obtained it in precipitating similar solutions under diverse conditions of temperature and strength.

Rigg is correct in his statement as to the possibility of obtaining a solution but little contaminated by iron by digestion with sulphuric acid. His remarks as to the incomplete solubility of the zinc in roasted ore are also well founded. In roasting ferruginous zinc ore there is formed a zinc compound, presumably the ferrate of zinc, which is insoluble, or partially insoluble, even in strong acid. This has been noted by many experimenters on the hydrometallurgical treatment of this class of ore. (*Vide supra.*)

Solomon Ganelin,[75] of Berlin, Germany, patented the process of mixing roasted ore with a molten metallic chloride, preferably the double chloride of zinc and sodium, whereby the metallic oxides are dissolved as oxychlorides or basic salts. The molten mass can be decanted from the gangue. When cool, it is treated with water, affording a solution of the salt originally employed and a precipitate containing the major portion of the oxides originally dissolved. Or the molten chlorides may be treated for the metals by fractional electrolysis.

Höpfner Process.—The technical results of the application of the Höpfner process at Führfort am Lahn in 1895-1897 were related by Dr. E. Guen-

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73 THE ENGINEERING AND MINING JOURNAL, April 25, 1903.
74 THE ENGINEERING AND MINING JOURNAL, May 30, 1903.
75 United States Patent 741,653, October 20, 1903.

ther in a paper[76] which it is impossible to condense. Dr. Guenther considers that the process was a technical success and estimates that there should have been a profit in the operation, but according to his figures the margin appears small.

K. Kaiser[77] proposes to treat roasted ore with sufficient zinc chloride to agglomerate the mass, forming oxychloride. After drying, the mass is crushed and treated with chlorhydric acid, preferably while hot. In about 15 minutes all of the zinc should be dissolved and but little if any iron present. The solution is electrolyzed with insoluble anodes and zinc (or iron) cathodes, which may advantageously be made cylindrical, and rotated.

M. Malzac[78] mixes oxidized ore with quicklime and leaches with ammonia water, draws off the solution and distills in a vacuum, precipitating zinc hydroxide suitable for use as a pigment.

W. Strzoda[79] states that zincate solutions can be electrolyzed in special apparatus with but little trouble, deposition of spongy zinc being avoided if air be blown under pressure into the solution and sand be thus kept in constant motion in the liquid, so as to scour the electrodes. The current density should not exceed 50 amp. per sq. meter. Processes in which the ore is introduced into the electrolytic vat to be dissolved do not readily yield pure zinc. F. Peters found that the Strzoda process (Germ. pat. 118,291) in which the ore is placed on the cathode, in an electrolyte of caustic soda, gave superior results to those processes in which the ore is placed on the anode. A copper cathode and carbon anode were used in the experiments, with a 10 per cent solution of caustic soda and finely crushed calamine containing 5.8 per cent zinc. With a pressure 3.2 volts, 1.6 gram of zinc was deposited by 10.3 ampere-hours. With flue-dust containing 10 to 12 per cent zinc, a metallic product assaying 80 per cent zinc was obtained, which by distillation gave a spelter with only 0.24 per cent lead, the cost of the zinc thus distilled being 22 to 24 marks per 100 kg. Strzoda says the choice of material for insoluble anodes in aqueous electrolysis is of great importance. Carbon is still the best. The ferro-silicon material patented by Höpfner has been unsatisfactory in its power of resistance. There is ground for hope that a practicable iron alloy will be devised. The electrolysis of zinc chloride solutions is beset with difficulties; the difficulties attendant on sulphate electrolysis are even greater.

MANUFACTURE OF ZINC WHITE AND LITHOPHONE.

William J. Armbruster,[80] of St. Louis, Mo., patented the manufacture of an improved lithophone, consisting of a mixture of barium sulphate, barium

76 The Engineering and Mining Journal, May 16, 1903.
77 French Patent 333,773, July 11, 1903.
78 French Patent 329,079, February 4, 1903; addition, 2,001, June 29, 1903.
79 *Chem. Ztg.*, 1903, XXVII, 741-743.
80 United States Patent 719,415, February 3, 1903.

carbonate and zinc sulphide. This is produced by adding a solution of barium sulphide to a mixed solution of zinc sulphate and sodium carbonate, when the following reaction takes place:

$$ZnSO_4+Na_2CO_3+2BaS=BaSO_4+ZnS+BaCO_3+Na_2S.$$

The sodium sulphide remains in solution and after separation by filtration is saved by evaporation and crystallization. Barium carbonate is averred to be a superior pigment to the sulphate, having more body and opacity and being more smooth and unctuous. "In practice it is found that when precipitated barium carbonate is substituted for the sulphate, either wholly or in part, when combined with zinc and lead whites the resulting pigment works smoother and finer, grinds easier in oil, flows more readily from the brush and spreads more easily under the brush."

Ferdinand Brünjes,[81] of Langelsheim, Germany, patented the process of obtaining zinc sulphide from slags, containing zinc (as oxide) and calcium, barium and iron (as sulphides), by treating the pulverized slag with sufficient muriatic acid to convert the calcium, barium and iron into chlorides, the sulphureted hydrogen set free precipitating zinc as sulphide. A charge of 1,000 kg. of slag, treated with 1,000 kg. of commercial muriatic acid and 250 kg. of water, is decomposed in 30 minutes, during which the temperature rises to 120° C. The zinc sulphide remains for the most part floating in the solution, from which it can be separated by filter-pressing, which is effected easily, the silica becoming quite insoluble at the temperature of the decomposition. The filtrate, which is of 1.28 to 1.30 sp. gr., lets fall half of its chloride of barium on cooling, the remainder being recovered by evaporation to 39 or 40° B and crystallization.

William D. Gilman,[82] of Baltimore, Md., patented the process of making lithophone and Glauber salt, which consists in adding to a solution of niter cake an excess of zinc, producing zinc sulphate and sodium sulphate, both in solution, to which the addition of barium sulphide throws down the mixed precipitate of barium sulphate and zinc sulphide (lithophone), leaving sodium sulphate alone in solution. The zinc is added in the form of skimmings, spelter, or acid-soluble ore. Iron is precipitated from the solution by chloride of lime and milk of lime, or any other convenient method.

Prof. Oettli[83] patented the process of electrolyzing a hot solution of sodium sulphate with zinc electrodes. Zinc sulphate is produced at the anode and sodium hydroxide at the cathode. These react with precipitation of zinc hydroxide and regeneration of the electrolyte. The zinc hydroxide is calcined to produce pigment. The production of 1,000 kg. of oxide per 24 h. requires 96 e. h. p.

B. H. Thwaite and T. J. Denny,[84] of London, patented the process of mak-

81 United States Patent 733,000, July 7, 1903.
82 United States Patent 732,732, July 7, 1903.
83 French Patent 328,491, January 14, 1903.
84 British Patent 18,015, August 16, 1902.

ing zinc white by burning granulated spelter in an electric furnace through which a current of air is forced.

W. George Waring,[85] of Webb City, Mo., patented the process of extracting zinc from mixed ores, which consists in leaching the ore with acidulated water, containing not more than 1.5 per cent of free sulphuric acid, and an indefinite amount of ferric sulphate, whereby a solution of zinc sulphate is obtained, precipitating metals of the copper group by addition of a slight excess of a soluble sulphide, and finally precipitating the zinc as sulphide by means of sulphureted hydrogen, the solution being heated to 150°-180° F. in order to effect complete precipitation and regenerate the acid for further use. Under the special conditions, described in detail in the patent, complete precipitation of the zinc can be effected. The precipitate of zinc sulphide is partially roasted to neutral sulphate. Another portion is treated with muriatic acid to obtain zinc chloride. A mixed solution of zinc sulphate and chloride is precipitated with an emulsion of magnesia suspended in a solution of barium chloride (produced by reducing barium sulphate to sulphide and treating the latter with muriatic acid). The precipitate consists of a mixture of zinc oxide and barium sulphate (in any desired proportion), which is marketable as a pigment.[86] Sulphureted hydrogen is produced by passing sulphurous gas from roasting furnaces into a strong solution of sodium sulphate, forming acid sodium sulphate, precipitating barium sulphite by means of barium carbonate and regenerating sodium sulphite, reducing barium sulphite to sulphide by furnacing with carbon and regenerating barium carbonate by treating the solution of sulphide with carbon dioxide, at the same time liberating sulphureted hydrogen.[87] This process is being tested at Webb City, Mo.

DETERMINATION OF ZINC.

A. Hollard described an electrolytic method for the separation and determination of zinc.[88]

W. George Waring, in a very important paper, pointed out numerous inaccuracies in the ferrocyanide titration of zinc, showed how to obviate them, and described a new method, which appears to be useful.[89]

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85 United States Patent 718,554, January 13, 1903.
86 United States Patent 718,555, January 13, 1903.
87 United States Patent 718,556, January 13, 1903.
88 *Bull.* Soc. Chim., XXIX, vii, 266-269; *Journal* Society Chemical Industry, 1903, XXII, viii, 512.
89 *Journal* American Chemical Society, January, 1904.

A REVIEW OF THE GENERAL LITERATURE ON ORE DEPOSITS DURING 1903.

BY J. F. KEMP.

As one gives a backward survey over the work of the past year in the investigation of ore deposits, the impression of continued and vigorous activity is strong. The general subject seems firmly established in the minds of geologists and engineers, and the irresistible attractions of its fascinating although elusive problems have invited and fixed attention. While we briefly review the results, the endeavor will be made to indicate the general bearings of the several papers rather than the particular records of facts.

The group of ores believed by many, if not all, investigators to result directly from igneous magmas by crystallization and segregation has always had one disputed member—the sulphides. That magnetites, usually titaniferous, and that chromite and corundum do separate and concentrate from molten masses is generally admitted, but regarding the true igneous nature of the nickeliferous pyrrhotite-chalcopyrite ore bodies in the outer edges of gabbroic intrusions, there have been doubts. Opponents and supporters have been equally vigorous in the expression of their views. To ordinary observation, as, for instance, at Sudbury, Ontario, the sulphides would certainly appear to be integral components of the dark, basic rocks. Nevertheless, some (as Posepny) have seen chemical difficulties in the way of an igneous origin, although on grounds not particularly strong; while others, and especially Beck, have recorded the evidence of brecciation and replacement. Microscopic study the past year on the part of two observers in widely separated localities, and the investigation of polished slabs have simultaneously led to the same conclusions. C. W. Dickson, in a dissertation upon the Sudbury ores,[1] has shown that the pyrrhotite and chalcopyrite are so related to the component minerals of the wall-rock as to necessitate the conclusion that they have been introduced in solution after the consolidation of the latter. The sulphides penetrate the smallest cracks in hornblende and other minerals, and are in such position as to preclude a development by crystallization from fusion. They favor also lines of faulting and brecciation, although invariably in the outer edges of gabbroic intrusions. From this it follows that some rearrangement and probable concentration have taken place, but, while duly admitting the soundness

[1] C. W. Dickson, 'The Ore Deposits of Sudbury, Canada.' *Transactions* American Institute of Mining Engineers, Vol. XXXIV, pp. 3–67.

of these conclusions, which are fortified by many plates, we must not overlook the significance of the invariable association of the nickel, copper and iron minerals with one series of eruptive masses, their failure to appear in any of the numerous other, and often faulted, rocks in the Sudbury region, and the genetic connection with the eruptive phenomena which seems to be thereby indicated. The introduction of the ores seems to have taken place probably in the expiring stages of the deep-seated vulcanism. Much the same conclusions have been reached by geologists working in the same region, both under the Dominion and Provincial auspices. In Dr. Dickson's dissertation, the chemical constitution of pyrrhotite, the relations of the nickel and the associations of the platinum mineral sperrylite are incidentally treated at length.

At the same time with Dickson's work an interesting paper appeared from the pen of Professor Richard Beck[2] of Freiberg, upon a new discovery of nickeliferous pyrrhotite and chalcopyrite, which in commercial amount are found along the outer portion of a proterobase dike. The proterobase, with some peculiar variations and some associated diabase dikes, occurs at Sohland, in the valley of the Spree, and almost on the boundary of Saxony and Bohemia.

Professor Beck draws the following conclusions: 1. The sulphides now occupy spaces which were originally taken up by the primary components of the rock. 2. They are associated with secondary, non-metallic minerals, especially actinolite and chlorite. 3. They favor those places where the alteration of the rock is especially pronounced. 4. They occur in all varieties of the ore-bearing rock, although more particularly in the prevailing proterobase, but they are not exclusively limited to any of the associated eruptives.

Professor Beck concludes that the ores were derived from the deep-seated magma which gave rise to the dikes, and were introduced by thermal and pneumatolytic agents akin to those which so often produce tin ores on the borders of granite. By replacement they have occupied the spaces formerly filled by the silicates of the dike.

These two papers cast considerable additional light on this particular form of ore body, and bring out as well the importance of microscopic study in drawing conclusions. The influence of the igneous agents comes in during the process of cooling, making this the critical and important stage and water the chief vehicle.

Great interest has been excited all over the civilized world in the new developments in iron mining in northern Scandinavia. In two localities the operations are on a vast scale, and are certain to ship to British and German furnaces large contributions of ores, and thus to augment and reinforce the local sources of supply, which, especially in Great Britain, are a subject of serious concern. The enormous mass of magnetite at Kirunavara is believed to be

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2 R. Beck, 'Die Nickelerzlagerstätte von Sohland a. d. Spr. und ihre Gesteine.' *Zeitschrift* d. deutschen geol. Gesellschaft, 1903, p. 296.

much the largest single body of iron ore known the world over. It is situated about a hundred miles north of the Polar Circle, in Sweden, but its ore is shipped by rail southward to Lulea, a summer port on the Gulf of Finland, and northwest to Narvick on the Ofot fjord in Norway, where the harbor is open to the Atlantic all the year round. American geologists and engineers have learned directly about the deposits from the visits in this country of Messrs. Lundbohm and Dellwik, who have been actively associated in their development. A somewhat extensive literature has sprung up in connection with them, but recently in a review of Scandinavian iron ores Professor L. De Launay has added some interesting observations.[3] While it is the purpose here to remark the method of origin favored by M. De Launay, yet it may be stated in passing that the Kirunavara continuous ore body is 3.5 km. ($2^1/_3$ miles) long, 40 to 166 m. (130 to 540 ft.) thick, and inclined 60°. Above the water level, it is estimated to contain 233 million metric tons of magnetite carrying 65 per cent Fe. With each meter of descent 1,500,000 to 1,900,000 tons are gained, so that, with a depth of 300 m., 600 to 800 million tons must be present. If to this we add what has probably been removed by erosion, we reach a total of 1.5 to 2 billions of tons of ore, containing 1 to 1.3 billions of tons of metallic iron. The ore, while rich in iron, is quite high in phosphorus. It lies upon a foot wall of orthoclase porphyry rich in soda (keratophyre) with about 60 per cent SiO_2 and a hanging wall of quartz porphyry, likewise rich in soda (quartz-keratophyre), with about 71 per cent SiO_2. The footwall is older than the ore, and there is reason to believe the hanging later. The change of the foot to the ore is sharp and clean cut, as is that from ore to hanging, except at Luossavara, where the quartz-porphyry contains some fragments of ore. Below the footwall are syenites, and above the hanging are metamorphosed sediments.

Obviously in seeking an explanation of the method of formation of this deposit we have a very exceptional problem. Professor De Launay, in reviewing the ideas already suggested, and adding his own, mentions the following five hypotheses: 1. The ore is a basic, igneous segregation, but in acidic instead of in basic rocks, as is the usual experience. This is upheld by Högbohm, favored by Beck and opposed by Vogt. 2. The ore, a fragment of some deep-seated basic magma, lay for a time in a molten bath of acidic scorias like a button in a scorifier. But this is frankly admitted to be improbable. 3. The ore is an intrusive dike of magnetite; likewise improbable. 4. The ore is a vein of magnetite, as upheld by Törnebohm; likewise improbable. 5. The ore is a portion of a sedimentary deposit caught between two faults in porphyry, somewhat as are several masses of coal in the plateau of central France.

Incidentally M. De Launay, while not expressing himself positively, seems to rather favor a source in the footwall porphyry, which, on its eruption

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3 L. De Launay, 'L'Origine et les Charactères des Gisements de Fer Scandinaves.' *Annales des Mise* July and August, 1903.

(perhaps submarine), and as it cooled, emitted ferruginous compounds. The iron salt may have been ferric chloride which was oxidized; it may have been ferric sulphate, which was reduced to pyrite, the pyrite itself then undergoing oxidation and metamorphism. The iron compound thus yielded was subsequently covered by the later flow of hanging-wall porphyry, and tilted to its present position. But in whatever way the solution of the problem may be suggested, it is obviously no easy one, and quite exceptional processes may be necessary. One may draw the conclusion that there is no undue monotony in the study of ore deposits, and that observers should be prepared for the unusual and abnormal. We may not hope to refer everything to the normal or commonly observed processes in Nature.

In the remainder of the work, which is of great interest as a concise and easily accessible review of Scandinavian iron ores, the titaniferous magnetites are briefly treated, and the merchantable ores, chiefly of some sort of sedimentary origin, are described. In the end Professor De Launay suggests that the well-known characteristic associates of the Swedish magnetites, the leptinites, halleflintas, amphibolites and pyroxenites may all be forms of metamorphosed and silicified limestones.

As the Continental and British iron-masters have cast about for new sources of ore, Kirunavara and Luossavara have not been the only districts in Scandinavia which have received attention. On the contrary, Professor Vogt[4] has given an interesting summary of many earlier and more recent observations upon the magnetites and subordinate specular ores which are associated with Cambro-Silurian marbles in the Dunderland valley, almost on the Polar Circle in Norway. The ores range about 40 per cent Fe and 0.2 per cent P, and the exposures contain 80,000,000 tons available for open cuts above the water level. The expectation is to furnish annually by means of Edison magnetic concentration 750,000 tons of bessemer briquettes with 67 or 68 per cent Fe and .03 per cent P. Professor Vogt believes the ores to have originated in much the same way as have the present lake ores of Scandinavia, that is, as very pure bog ore deposits, which have later become metamorphosed. They suggest in many ways the Siluro-Cambrian brown hematites of the Appalachians, which, however, have been produced by the alteration in situ of ferriferous rocks, with some replacement of limestone, a derivation not suggested by Professor Vogt.

Professor Vogt has also recently published an extremely valuable work upon the study of slags,[5] and has traced the laws of the formation of artificial silicates, titanates, oxides, aluminates, ferrates, sulphides, phosphates, metals and metalloids, using, as the basis of his work, 155 slags of all sorts, whose compositions were accurately known. Very significant conclusions are reached regarding the general petrology of the igneous rocks, and incidentally regard-

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4 J. H. L. Vogt, 'Die Regional-metamorphosierten Eisenerzlager im nördlichen Norwegen' (Dunderlandsthal, u. s. w.), *Zeitschrift* für Prak. Geologie, January and February, 1903.

5 'Die Silikatschmelzlösungen,' Part I, 'Ueber die Mineralbildung in Silikatschmelzlösungen,' Christiania, 1903.

ing the igneous ores. Slags present simpler problems in many cases than do eruptive rocks, in that they often involve chiefly two bases, or two silicates whose mutual reactions can be traced and perhaps verified by fusion and cooling, with pyrometric records. With regard to the ores, magnetite is the one chiefly concerned, and no results are developed contradictory to our generally accepted conceptions regarding its separation and concentration in molten magmas.

In turning now from papers, whose mention, except in the case of the Dunderland iron ores, was suggested by their primary connection with igneous phenomena, one may take up those involving especially the circulation of subterranean waters. Conceptions have become quite sharply defined within the last few years. From time immemorial miners have known that there was an upper zone of varying depth, where excavations were not troubled with water, and below this a fairly definite horizon where the 'ground-water' began and pumping became a necessity. Posepny called the upper zone the 'vadose' region, and the lower the zone of the deep waters. From the earliest development of the intelligent mining of copper or lead ores, it must have been also known to the miners that the character of the ore customarily changed at or near the ground-water level. With the advent of chemical knowledge it was recognized that the upper or vadose zone had oxidized ores, and the lower, sulphides. In the case of copper, it has also been long recognized that at or near the water-level there was an horizon where the copper, leached by descending waters from the oxidized zone, was concentrated, forming what has been called the zone of enrichment.

The importance or the special bearing of more recent papers lies in the discussion of the sources of the ground-waters and their phenomena of subterranean movement, although incidentally other names have been applied to the several zones. Thus, instead of the vadose zone, we may with Van Hise speak of the "belt of weathering" forming a zone of solution or of active chemical change above the ground-water; while below is a "belt of saturation," precipitation and cementation in the deeper regions; in between lies the zone of secondary enrichment of the ores, which has been shown by him, Emmons and Weed to extend a notable distance below the upper surface of the groundwater. This last-named idea of enrichment to considerable depths below the level of the ground-water has been specially worked out from the deep occurrences of chalcocite as a secondary mineral in the mines at Butte, and it is a new and distinctly important discovery. The other points about the groundwater which are significant in this connection are its extent in depth, its sources and the relative importance of gravity or head, of the normal increase of temperature with depth, and of the heat locally contributed by igneous intrusions in causing it to actively circulate. The last two annual reviews of the literature have condensed the important papers bearing on these points, but they are mentioned here so as to establish a bench-mark from which one may trace a course. A summarized discussion will also be found in the little volume of discussion on 'Ore Deposits' issued by THE ENGINEERING AND MINING JOURNAL as No. 1, in its projected series of condensed discussions upon various topics connected with mining.

For several years past Mr. John W. Finch, recently State Geologist of Colorado, has been accumulating observations upon the subterranean waters met in mining in the Rocky Mountain region and more especially at Cripple Creek, where as we all know the pumping burden is very heavy. Between the zones of the vadose circulation and the deep-seated ground-waters (or by whatever names these two essentials may be called) Mr. Finch acutely interposes a "discharging zone," making thus "Zone I, the gathering zone"; "Zone II, the discharging zone"; "Zone III, the temporary and static zone."[6] The discharging zone embraces that portion of the underground waters which in any locality stands between the ground-water level and the lowest point of discharge at the surface of the earth for the water of this locality. Thus, in any region, the ground-water level roughly follows the contour of the surface, sloping, however, at a somewhat less abrupt angle. Beneath the side of a hill or mountain the waters above the neighboring valley feed the springs found along its base. That portion of the ground-waters above the horizon of these vents is in a condition of movement and is the reservoir feeding them. The ground-water below this level, forming Finch's Zone III, has under normal relations practically no movement, but is static unless its condition is locally and abnormally disturbed by some great line of fissuring or by an igneous intrusion, or both. Then, for a brief period, the waters of the static zone circulate, produce primary ore deposits, and having healed up the fractures, settle back into their old-time quiescent conditions. While the depths to which water in Zone III extends is somewhat conjectural, yet it is not believed to be ordinarily more than 1,000 to 1,500 ft., and in arid regions it may fail entirely. While at times of great fissuring it may and doubtless does go deeper, yet the fissuring is temporary, and old conditions are resumed after the lapse of a relatively brief time. Primary and comparatively lean ore deposits having been produced in this way, the importance of secondary enrichment in bringing to pass the conditions in veins as seen in mines to-day is, in the view of the author, enormously increased, and its discussion and the production of bonanzas constitute the second portion of this extremely interesting and important paper.

In a summary and review, necessarily brief, one cannot take up all the corollaries of the views presented, but the restriction of the subterranean waters to such moderate depths as are coincident with experience in mining rather than in accord with more subjective generalities; the exceptional catastrophic and comparatively brief causation and filling of veins, as against pro-

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6 John W. Finch, 'The Circulation of Underground Aqueous Solutions and the Deposition of Lode Ores.' *Proceedings* Colorado Scientific Society, 1904, Vol. VII, pp. 193-252.

tracted and slow-working normal processes; and the great importance attributed to secondary enrichments and rearrangements, all taken together, contribute much to the suggestiveness and originality of the views advocated.

Mr. Halbert Powers Gillette[7] has contributed a short paper upon the methods whereby minerals and ores may be brought to places of precipitation under the influence of osmosis, a factor whose importance it is urged has not been hitherto fully appreciated. Mr. Gillette attacks the problem along the lines of modern physical chemistry, and his argument, briefly expressed and so formulated that readers not familiar with the later phraseology of physical chemistry may grasp it, is this: When a salt goes into solution it spreads, or, as we used to say, diffuses itself far and wide in the solvent, being impelled thereto by osmotic pressure, which in a solution of sugar is about 20 lbs. per square inch. When a point of crystallization is established, more dissolved material will be forced by osmotic pressure toward the point of precipitation, in order to feed the growing crystals. Minerals forming the ore and gangue may therefore be collected, not by convection currents and actual flow of the solvent, but by passage, through standing solutions, much as the plating is deposited in an electro-plating bath. Variations in temperature and pressure would be important factors. Mr. Gillette does not, however, reject convection currents; on the contrary, he strongly urges their importance in several selected cases.

In earlier papers osmosis has been especially appealed to in connection with the segregation of ores in molten rock, such as the chalcopyrite-pyrrhotite aggregates referred to at the outset as occurring in the outer portions of gabbros. Dr. George F. Becker has, even for these cases, presented a strong controversial argument in favor of convection currents on account of the slowness of diffusion even under favorable circumstances,[8] and considerable circulation apparently must be assumed in order to bring to pass large deposits even within geological periods. Nevertheless, as bearing upon the solution and removal of finely disseminated metals and minerals, and as bearing on phenomena of replacement, Mr. Gillette's thesis is suggestive and of value.

A very interesting paper worked out along the lines of physical chemistry has been prepared by Sr. Juan D. Villarello, of the Mexican Geological Survey.[9] It is based upon the quicksilver deposits of Palomas and Huitzuco, in Durango and Guerrero. Rhyolite and basalt are in contact, and the former has been altered to a mass of kaolin, sometimes stained by iron. The cinnabar occurs in veins and veinlets of amorphous silica, which ramify through the kaolinized rhyolite. Senor Villarello refers their period of formation to the expiring or fumarolic stages of volcanic action, during which thermal springs

7 Halbert Powers Gillette, 'Osmosis as a Factor in Ore Formation.' *Transactions* American Institute of Mining Engineers, October, 1893.
8 G. F. Becker, *American Journal of Science*, Jan., 1897, p. 21; Oct., 1897, p. 257.
9 'Genesis de los Yacimientos Mercuriales de Palomas y Huitzuco.' *Memorias* de la Sociedad Cientifica 'Antonio Alzate," 1903, vol. XIX, pp. 95-136.

gave rise to them. Subsequent secondary reactions have also played a part. The chemistry of the process is traced out in great detail, the reactions being written on the basis of thermo-dynamic equivalents. The paper will prove of importance and suggestiveness to all who are investigating quicksilver deposits. It is also another instance of the growing disposition of geologists to express the chemical processes which have given rise to ores in definite reactions rather than in generalized statements.

In nearly all the more recent papers which have dealt with the lead, or lead and zinc deposits of the Mississippi valley and of southwestern Missouri (the exception being the contribution of W. P. Jenney), the writers have affirmed with somewhat dogmatic positiveness that meteoric waters have brought in the ores and have derived them from the sedimentary strata, such as now constitute the outcropping formations, or which have been removed by erosion from positions above the present sites of the ores. This thesis has often seemed far from proven to those of open minds, who have seen the ore deposits, and it is of special interest, therefore, to note that H. A. Wheeler,[10] whose many years of familiarity with southeast Missouri give his conclusions great weight, has referred the lead to a deep-seated source and has explained its introduction by the uprising waters in which the mining geologists of earlier years have generally placed their confidence.

In contrast with the above conclusions is a recent paper by A. C. Lane,[11] upon the source of the copper in the deposits on Keweenaw Point. Dr. Lane favors descending waters, in large part, because the present more productive mines appear to be located beneath the highest portions of the Point, whereas lower lying claims have proved less remunerative. The inference, therefore, is that meteoric waters in their percolations from higher points to lower exits have had special advantages in the former for taking copper into solution from the rocks and losing it by precipitation during the downward course. A reader, cannot, however, on reflection, avoid raising the question as to the geological date of the enrichment, and as to the similarity which the topographic outlines of that time bear to the present relief of the Point.

The wall rocks are very old, and the general fact that the native metal, usually a gossan mineral, now extends to depths, thousands of feet below both the upper and the lower limits of the present ground-water, may well make one wonder if old conditions were not very different from modern ones.

Interest continues in the type of ore-body involving the presence of slightly auriferous chalcopyrite in garnet zones, produced from limestones by the contact effects of igneous rocks. Mr. George Smith has written of one in North Queensland.[12] The garnet rock is regarded as itself a distant eruptive, but

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10 H. A. Wheeler, 'Notes on the Source of the Southeast Missouri Lead.' The Engineering and Mining Journal. March 31, 1904. p. 517.

11 A. C. Lane, Advance sheets in *Michigan Miner*, Jan. and Feb., 1904.

12 George Smith, 'The Garnet Formation of the Chillagoe Copper-Field, North Queensland, Australia, *Transactions* American Institute of Mining Engineers, October, 1903.

in the discussion of the paper Mr. H. W. Turner upholds its more probable nature as a contact zone.[13] Mr. Turner has also recorded five new garnet zones in the Sierra Nevada, while Professor W. P. Blake has described a considerable number in the southwest.[15] Lastly Mr. F. L. Ransome brings under the same type the great copper deposits of Bisbee.[16] which, however, have needed alteration and localized secondary enrichment in order to render them commercially valuable. Microscopic study has thus led to the correct interpretation of the hitherto somewhat obscure wall-rocks of the ores.

Mr. Ransome has also prepared a more elaborate paper upon the Globe copper districts of Arizona[17] and has recorded the details of a region regarding which all too little has been accurately known. Faulting of the most elaborate and intricate character is revealed. The ore deposition followed the entrance of great intrusive sheets, irregular masses and dikes of diabase which are post-Carboniferous. It is, therefore, considered to be Mesozoic in age. The ore is believed to be derived from the diabase in the stages of expiring vulcanism, and, as is usual in Mr. Ransome's papers, although somewhat surprising, considering his wide experience with eruptive rocks in the West, meteroic waters are the only vehicles considered. Reflection upon the well-established phenomena of active volcanoes and upon the conclusions of some of our best observers of thermal springs must convince a candid mind of the importance of magmatic waters. Beginning as somewhat lean pyritic deposits, alteration, concentration and subsequent oxidation have given the ores commercial value.

In connection with this paper, we may note the new form in which the publications of the United States Geological Survey now appear. Instead of the ponderous annual reports of earlier years, the contributions which would have constituted them are now issued as rapidly as prepared under the name of *Professional Papers.* Quicker distribution is thus gained, and papers go to those most interested without the handicap of much additional material, which by one reader and another may not be desired. In the *Bulletins,* moreover, the custom has been introduced of an annual number on economic geology, which gives brief and concise summaries of work in many regions, West and East. Separate and shorter papers on economic geology may constitute entire bulletins as well, such as Mr. J. E. Spurr's interesting and timely description of the Tonopah district.[18] The abundant faulting of this region and the remarkable and exclusive association of the ores with the oldest volcanic rock in a series of seven different kinds give the paper special scientific importance. The United States Geological Survey has been putting forth every effort to

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13 H. W. Turner, Discussion of same. *Idem.*
14 H. W. Turner, 'Notes on Contact-Metamorphic Deposits in the Sierra Nevada Mountains.' *Idem*
15 W. P. Blake, 'Copper Ore and Garnet in Association.' *Transactions* American Institute of Mining Engineers, Vol. XXXIV, pp. 886-891.
16 F. L. Ransome, 'The Geology and Copper-Deposits of Bisbee, Arizona.' *Transactions* American Institute of Mining Engineers, February, 1903.
17 F. L. Ransome, 'Geology of the Globe Copper District, Arizona.' Professional Paper No. 12, U. S. Geological Survey, 1903.
18 J. E. Spurr, 'The Ore Deposits of Tonopah, Nevada,' *Bulletin* 219, U. S. Geological Survey.

supply much needed information regarding Alaska, and some excellent papers have been prepared,[19] involving the record of not a few significant phenomena. In completing the work in the Lake Superior iron region two monographs have appeared, making the list of the special ones on individual districts practically complete. The latest are those respectively on the Mesabi range by C. K. Leith[20] and the Vermilion range by J. M. Clements.[21] The Archæan, as distinct from Algonkian, age of the rocks affording the ore in the latter is a striking fact. In other respects, the general conclusions regarding the formation of the ores, as hitherto reached in the older ranges, hold good. The concluding general monograph upon the several ranges as a whole and from the pen of President Van Hise remains to be issued.

A very excellent piece of structural work upon an extremely obscure problem has been done by H. L. Smyth and Philip S. Smith,[22] whose results have appeared in THE ENGINEERING AND MINING JOURNAL. The authors have been studying for several years past the lenticular copper deposits of the eastern Green Mountains in Vermont, and have reached the conclusion that they occur in the schists along fractures formed by faulting and folding. The origin of the ores is referred to pneumatolytic action, probably from the influence of neighboring intrusions of eruptives. The lenticular type of deposit of pyritous ores in metamorphic rocks is one of the most puzzling and difficult in the wide range of experience, and the structural relations are exceedingly elusive. This paper may well prove suggestive for other occurrences.

With regard to the early history of the earth, and as a partial alternative to the nebular hypothesis, a new and contrasted conception has been presented by Professor T. C. Chamberlin[23] under the name of the "planetesimal hypothesis." The earth is conceived to have originated, not directly from a highly heated gaseous nebula, as in the old view, but by the aggregation of multitudes of small individual and cold masses of matter, technically called planetesimals, a word coined from analogy with the mathematical term infinitesimal. The planetesimals are believed to have fallen together and to have built up the globe. Internal heat results from the growing pressure caused by the attraction of gravitation. Volcanic phenomena, dislocations and other geological phenomena, so far as they are related to the beginning of the planet and are affected by our old conceptions of the nebular hypothesis, are likewise bound up in this newer view. Nevertheless, the more reliable reasoning on the phenomena of ore deposition begins at much later stages, and is concerned

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19 A. H. Brooks, 'Ketchikan Mining District.' Professional Paper No. 1. W. C. Mendenhall and F. C. Shrader, 'Mineral Resources of the Mt. Wrangell District.' Professional Paper No. 15. F. C. Shrader, 'Reconnaissance in Northern Alaska,' Professional Paper No. 20.

20 C. K. Leith, 'The Mesabi Iron-bearing District of Minnesota,' *Monograph* XLIII.

21 J. M. Clements, 'The Vermilion Iron-bearing District of Minnesota,' *Monograph* XLV.

22 H. L. Smyth and Philip S. Smith, 'The Copper Deposits of Orange County, Vermont,' THE ENGINEERING AND MINING JOURNAL, April 28, 1904.

23 The planetesimal hypothesis was explained to the Geological Society of America at the Washington meeting, Dec., 1902. A further discussion took place at the St. Louis meeting, Dec., 1903, as a preliminary to which appeared the article by H. L. Fairchild on 'Earth Origin,' under the auspices of the Society. Further discussions by F. R. Carpenter and N. F. Edwards (*Proc.* Col. Sci. Soc., 1904, VII, 253-266 and 289-296) and by Persifor Fraser (*Trans.* Amer. Inst. Min. Eng., 1904) have appeared.

with causes having remote connections with planetary forms of origin. They are, moreover, based upon much sounder evidence than these speculative themes. The natural and safe disposition of the mining geologist, especially if he have also, as is desirable, the cast of mind of the engineer, is to busy himself with the facts of structure and with the causes which lie near at hand; but so much is claimed for the new hypothesis, and so many things, now quite satisfactorily explained without reference to it, are corralled by its supporters as to make one infer that the sweeping statements were advanced chiefly in the hope of provoking discussion.

The election of Mr. S. F. Emmons to the presidency of the Geological Society of America in 1902 was hailed with the liveliest satisfaction by all interested in the problems of ore deposition and development. The long experience, excellent poise and many contributions of Mr. Emmons have given him an unrivaled place in the estimation of all American workers. The grace of his literary style, moreover, embodying as it does at once clearness and felicity of expression, has served as a model and a stimulus to not a few younger workers. Mr. Emmons happily chose as the theme of his presidential address, 'Theories of Ore Deposition, Historically Considered,'[24] and in it traces the progress of the various views from their early beginning to their latest forms of expression. A suggestive and interesting panorama is unfolded before the mind of the reader.

Within the past year, also, Professor Richard Beck has issued a second edition of his treatise on 'Ore Deposits' ('Lehre von den Erzlagerstätten'), a most valuable and beautifully illustrated work. Mining geologists in all parts of the world will rejoice that the inspiring traditions of the ancient mining academy at Freiberg, coming down from Werner and von Cotta, are fully maintained by the present professor of geology.

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24 *Bulletin* No. XV, Geological Society of America, 1904, pp. 1-28.

REVIEW OF THE LITERATURE ON ORE DRESSING IN 1903.

BY ROBERT H. RICHARDS.

CRUSHING MACHINERY.

A New Ore Breaker.—This breaker, made by W. R. Martin Iron Works, Lancaster, Pa., is of jaw type with pitman-and-toggle movement.[1] The body is cast in one piece, and the swing jaw and pitman are very heavy and strong. Jaw plates are made of special mixture of hard iron and are chilled. The sizes vary from 10 by 7-in. opening to 20 by 10 in., requiring from 8 to 15 h. p. The capacity varies from 8 to 15 tons per hour, according to size.

The Blake Breaker.—In a long article William P. Blake[2] describes the Blake breaker, discussing its invention, forms and modifications, and its importance in engineering industries.

The Krom Breaker.—The breaker is built in small sections and can be easily shipped.[3] The movable jaw is pivoted at the bottom, and on the crushing surfaces are removable plates which can be renewed when worn. The toggles roll in their sockets so that no oil is needed, and there is but little friction.

The Wallace Breaker.—The Wallace steel breaker[4] breaks 12 to 36 tons per day to ¾ or ⅛ in. size, and its product is said to be well adapted to jigging. The class to which the breaker belongs is not made clear.

The Heclon Breaker.—The Heclon ore breaker[5] was designed by R. A. Hadfield and A. G. M. Jack. It is a gyratory breaker somewhat similar in its adjustment to the Gates. The shaft is hollow and carries the crushing cone. It is supported by means of a ball and socket on top of a fixed shaft, which is revolved in an eccentric motion. It is claimed to give a uniform product due to the special form of crushing surfaces. It is made mostly of steel.

The Ferraris Ball Mill.—W. R. Ingalls[6] describes the Ferraris ball mill. He says it is especially adapted for wet crushing. It has a steel drum divided into two compartments by a perforated annular partition. The larger compartment, into which the ore is fed, is lined with hard steel plates and contains the usual balls for crushing the ore. The smaller compartment is divided into

1 *Iron Trade Review*, Vol. XXXVI, May 14, 1903, p. 51.
2 *Transactions* of the American Institute of Mining Engineers, Vol. XXIII, 1902, p. 988.
3 *Mining and Scientific Press*, Vol. LXXXVI, 1903, p. 201.
4 *Mining and Scientific Press*, Vol. LXXXVI, p. 24.
5 THE ENGINEERING AND MINING JOURNAL, Vol. LXXV, 1903, p. 712.
6 THE ENGINEERING AND MINING JOURNAL, Vol. LXXVI, 1903, p. 811.

a series of pockets by means of a cone projecting into the larger compartment and a series of radial partitions extending therefrom. The ore is given a preliminary grinding in the first compartment and, if small enough, goes through the partition to the second, and, when ground fine enough, through the discharge screen at the end. Oversize is elevated by means of the radial partitions and cones, and sent back to first compartment for further grinding. It is claimed these mills are more economical than stamps and rolls. They are used at Montiponi, Sardinia and Durfort, France.

Regrinding Mills.—It is stated[7] that at the present time tube-mills are giving the best results for fine grinding previous to chemical treatment. On the other hand as they make a large amount of slimes they are not satisfactory for grinding when concentration is to be used. Down to 30 mesh, rolls are best; then come ball mills, but they cost more and their product is more uneven. Huntington mills are doing good work at Anaconda and Great Falls. Chilean mills are cheap to run, but they are heavy and repairs are quite hard to make. In the Lake Superior region steam stamps, while they have proved the most efficient machines for crushing copper rock, have given poor satisfaction on re-crushing middlings, as the product is uneven in size and they make a pulp poorly suited to further treatment. Rolls are employed at Anaconda and Great Falls on the coarser middlings, but do not commend themselves for wet crushing to sizes below 1.5 mm., or about 12 mesh, No. 22 wire.

The Krom Rolls.—The Krom cushioned rolls are described,[8] the principal feature being crushing springs carried in cages. These springs do not yield under ordinary crushing strains, but do yield if iron gets into the rolls.

The Humphrey's Rolls.—The design of the new Humphrey's rolls[9] includes simple means for keeping the rolls in proper alignment, and for preventing the loosening of the bearing caps, as well as making it possible to separate the rolls quickly in the event of the machine becoming clogged in any way.

The Fritsch Crushing Rolls.—The Fritsch rolls are briefly described.[10]

Concentrating Machinery.

The Pinder Concentrator.—This concentrator consists of a nearly circular surface bounded by an outer rim.[11] The surface is a flexible pan, 8 or 9 ft. in diameter, with an aperture in the center; its slope may be adjusted as the conditions vary. The surface is covered with linoleum and upon it are laid 56 brass or copper riffles ¾in. apart, all starting from a line that curves toward the center, each taking a spiral course to conform to the circular shape of the pan. Each riffle terminates in a feather edge. The outer riffle is

7 The Engineering and Mining Journal, Vol. LXXVI, 1903, p. 164.
8 *Mining and Scientific Press*, Vol. LXXXVI, 1903, p. 262.
9 The Engineering and Mining Journal, Vol. LXXVI, 1903, p. 624. Illustrated.
10 The Engineering and Mining Journal, Vol. LXXV, 1903, p. 339.
11 The Engineering and Mining Journal, Vol. LXXVI, 1903, p. 933.

far enough from the rim to leave a clear smooth space between it and the rim, and each succeeding riffle is placed a little nearer the center, and the feather edge of each extends a little farther than the preceding. The feed box is placed near the head of the riffle system where the pulp is fed. The water is discharged at various points around the rim through jets from a pipe. The concentrates discharge at the forty-second riffle and at the end of the riffle system. The tailings discharge at the aperture in the center. The outer edges are supported on six standards which act as bearings. A spiral spring attached to each bearing takes up lost motion, and prevents vibration and draws the pan one way, reciprocating with the motion imparted by a toggle-driving mechanism. The motion produced is aimed to imitate that of a gold pan.

The Card Concentrating Table.—This is a riffle table of the Wilfley type. The main points are a series of channels or riffles, having a cross-section like that of a gold pan.[12] From a narrow and shallow section at the feed end the channels expand up to one-third the length of the table and there contract to the discharge end. When the table is loaded the surface is smooth. This arrangement of the surface is claimed to cause the fine concentrates to settle to the bottom of the channel and to be pushed to the discharge end by the coarser concentrates. The feed is through a hydraulic sizer, and the fines are fed ahead of the coarse and are carried along by the greater impetus of the latter. The motion is imparted by push bars, crank and pitman, and is of a differential character. The forward motion is accelerated and the return is retarded. The machine occupies a space of 5.5 by 18 ft.

A New Overstrom Table.—An Overstrom concentrator of an improved pattern, manufactured by Allis-Chalmers Company, is described as made of structural steel and iron excepting the top.[13] Three features of special improvements have been made, viz., head motion, reciprocating motion and carrying mechanism of the table top. The motion is imparted to the table by means of rocking arms at the head and tail ends of the table, the arm at the head end being connected with the head motion by means of a connecting rod and cast steel yoke. The rocking arm at the tail end engages the spring, which is held in an adjustable seat. The arms are carried on steel shafts, and the table is always in tension by means of the springs at one end and the head motion at the other. The reciprocating motion, which tends to bring the particles of ore forward in the direction of the line of reciprocation, has greater action on particles of mineral near the table surface than the light gangue that rides on top. The table top rides on four steel rollers and has double taper riffles 1/32 in. high at the head end, increasing to 3/16 in. at a distance of 6 ft. and decreasing to a feather edge 20 in. from the discharge end. The top is diagonal to the line of reciprocation, and the flow of

12 *Mining Reporter*, Vol. LXVII, p. 516.
13 *Mining Reporter*, Vol. XLVIII, October, 1903, p. 357.

water tranverse to this line. Gravity acts on the mineral vertically and the reciprocating motion and water act in horizontal lines.

The Acme Concentrator.—This machine is a rectangular-shaped table which operates much the same as the Wilfley.[14] Instead of riffles there are four rows of cup-shaped depressions varying from 6 in. diameter and 3/8 in. deep at the feed end to 2 in. diameter and 1/8 in. deep at the discharge end. Each row of cups is connected by a longitudinal groove along which the concentrates move. There are three or more tables arranged in terrace so that the subsequent tables are fed with the middlings from the one before it.

A New Round Table.—The riffled table made by the Union Iron Works is undergoing a trial at the North Star mill of Grass valley. It has a surface in the form of a very flat cone, highest in the center, which is so hinged, jointed and braced with its linoleum top that its slope from center to margin may be varied from perhaps 0.25 in. to the foot up to 1.5 in. to the foot. Upon this surface are circumferential riffle cleats, tapering to a thin edge. The inner cleat is ended up earlier than the outer one, the others ranging from one to the other. The table is given a circumferential vanning motion, moving the concentrates towards the tapered points of the riffle cleats, while the quartz rolls over the cleats towards the margin.

The Berrigan Centrifugal Separator.—The slimes to be unwatered are fed from above into a bowl or cylinder which revolves at a high speed within an outside shell.[15] The heavy material is thrown out to the sides of the shell, where it is forced up an incline by scrapers on the central spindle. It is claimed that the waste water carries only 1% pulp, and the pulp separated contains but 3% moisture. The machine operates at 2,000 to 2,500 r.p.m. The capacity is claimed to be sufficient to handle the tailings from at least 10 stamps.

A New Slime-Saving Device.—This device, invented by A. R. Wilfley and installed in H. E. Wood's testing works, is described by the inventor[16] as follows: It is essentially an appliance to save the losses of concentrating tables, and will save, it is claimed, 25 to 60% of the value lost by other machines. It consists of a revolving endless belt, carrying a series of transverse troughs with canvas surfaces. The Wilfley differential motion is attached to the upper end, causing a varying motion in the direction of the length of the troughs or across the endless belt. A long feed box is placed along the upper end, into which the pulp is conveyed about two-thirds the length of the belt. The rest (that is one-third) is used for washing with clear water. The belt is almost horizontal and the material is 'progressed off' instead of being washed off. The mineral adheres to the canvas and is carried over the end on the belt where it is washed off by means of a spray.

The Sperry Vanning Buddle.—This is a modification of the Cornish round

14 *Mining Reporter*, Vol. XLVIII, 1903, p. 436. 15 *Mining Reporter*, Vol. XLVIII, 1903, p. 258.
16 *Mining Reporter*, Vol. XLVII, 1903, p. 518. *Mining and Scientific Press*, Vol. LXXXVII, 1903, p. 202.

table[17] and has the following features: (1) Circular form of table; (2) a rotating table with fixed points of feed and delivery; (3) a circular vanning motion; (4) an adjustment of size and space of vanning; (5) an adjustment of the rotary motion; (6) an adjustment of the slope of the top which can be made when the machine is in motion.

The Brownell Frue Vanner.—This is an improvement on the Frue vanner, retaining all the good points but improving the general construction and durability.[18] It is made of iron, thus doing away with the cumbersome wooden frame. There is an improvement for starting and stopping the uphill travel of the belt. New ideas for driving and regulating the travel of the main belt have been introduced.

Isbell's Improved Hydraulic Sizer and Classifier.—Instead of depending on the volume of water passing up the throat to do the work, thereby flooding the fines, this machine accomplishes the work by a regulation of the pressure.[19] The water enters a vertical pipe and passes upward. The pipe terminates just below the throat of the classifier. In the end of this pipe is a ball valve around which the water passes to get to the sorting chamber. By allowing more or less movement to this ball, the quantity of water is regulated and hence the limits of classification.

The New Century Jig.—The New Century drop-motion jig gives a rapid downward movement to the plunger, followed by a slow return movement.[20] The latter is actuated by a gently-curved spiral cam acting through a roller on the plunger rod. The former movement is caused by a stiff steel spring and can be regulated by suitable nuts as to amount of throw and speed of movement while the machine is running. The sieves are provided with side discharges which draw their products from the tail end of the sieves and from the whole width evenly. The sizes of compartments used are 36 in. long by 24 in. wide.

The Hambric Classifier.—A description with cuts is given of the Hambric hydraulic classifier,[21] in which the sorting column is a vertical iron pipe supplied with clear water by a smaller pipe dropped in from above, and discharging through many small holes pointing in different directions and at different heights. This sorting column is placed at the bottom of a V-shaped tank. It is used at the Leila mill, Jackson, California, and sends its overflow to canvas tables, while the spigot product goes to waste.

The McDermott Sizer.—The machine is a combination of a jigging current with sets of submerged inclined screens to size a crushed product before it goes to the concentrators.[22] Details of working and operation are given.

A Screening Tower.—The great screening tower at Fleusburg is described.[23]

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17 *Transactions* of the American Institute of Mining Engineers, October, 1903.
18 *Mining and Scientific Press*, Vol. LXXXVI, 1903, p. 120.
19 *Mining Reporter*, Vol. XLVII, 1903, p. 78.
20 *Mining and Scientific Press*, Vol. LXXXVII, 1903, p. 148.
21 *Mining and Scientific Press*, Vol. LXXXVII, 1903, p. 83.
22 THE ENGINEERING AND MINING JOURNAL, Vol. LXXV, 1903, p. 335.
23 *Dinglers' Polytechnisches Journal*, Vol. 318, p. 160.

The ore is fed in at the top and passes over a number of zigzag screens which separate the ore-stream into several sizes; under each screen is a chute to carry off the undersize. The oversize of all the screens passes out at the bottom.

General Milling Practice.

Milling in the Cœur d'Alene, Idaho.—J. R. Finlay[24] states that the practice of the Standard mill which he describes is representative of the district. The crude ore, which consists of galena, siderite, blende, pyrite and quartz, is received in a 600-ton bin from the mine at a cost of 8 to 20c. per ton, and from here is sent to a No. 5 Gates breaker which crushes it to 1 in. A 15-in. belt conveyor takes it to another bin, whence it passes to rolls which crush to 0.5 or 0.67 in. The product is sized by two trains of trommels which have holes 15, 10, 7 and 3 mm. in diameter. The material coarser than 15 mm. goes to "bull jigs" which yield tailings (waste) and middlings. These are crushed to 40 mesh by rolls and Huntington mills. The stuff between 15 and 3 mm. goes to fine jigs. These make concentrates, tailings (waste) and middlings. The middlings are treated like those of the coarse jig, and all are sent with the material finer than 3 mm. to hydraulic classifiers. The spigots and heavy part of the overflow are treated on Wilfley tables and Frue vanners. The tailings from these, also the slimes from the classifiers, are run over 52 canvas tables, each having 6 sq. yd. surface. The concentrates are reworked on two Wilfley tables. The mill dresses about 500 tons per day at a cost (mining and milling) of \$2.50 to \$3.50 per ton, and a loss of values of from 20 to 30%. The equipment comprises a No. 5 Gates breaker, two 15-in. belt conveyors, six sets of 15 by 26-in. rolls, four 5-ft. Huntington mills, 28 Hartz jigs (arranged in 14 pairs), two lines of trommels, an oversize trommel for middlings, four elevators, 18 Wilfley tables, three 4-ft. Frue vanners and 52 canvas tables. The power for the main mill is derived from a 4-ft. Pelton wheel, under 32 ft. head, and a 6-ft. Pelton under 235 ft. head. A 24-in. wheel under 235 ft. head furnishes power for the electric light plant, and another runs the Gates breaker.

Milling Practice at Creede, Colorado.—The Creede mining camp, Colorado, is essentially a silver-lead camp. In a paper by Arthur Lakes[25] numerous mines are mentioned and the milling operations at the Humphreys plant are given as a type of the rest. The ore is trammed from the mine through the Nelson tunnel, and over a surface tram to the mill, where it is dumped into storage bins of 600 tons capacity. The following system of concentration is used:

(1) Grizzlies; oversize to (2), undersize to (3).
(2) A 10 by 28-in. Blake breaker to (3).

24 The Engineering and Mining Journal, Vol. LXXV, 1903, p. 87.
25 *Mines and Minerals*, Vol. XXIII, 1903, p. 433.

(3) Roughing screens, 3 by 3 ft., to (4).
(4) Automatic sampler to (5).
(5) Two pair 14 by 36-in. Jackson rolls to (6).
(6) Elevator to two lines of revolving screens of 4 screens each, 3 ft. in diameter and 6 ft. long; undersize of finest screen to (9), oversize of coarsest screen by means of Frenier sand pump to (5); intermediate sizes to (7).
(7) Twelve 4-compartment Hartz jigs; concentrates to bin, middlings and tailings to (8).
(8) Three sets 14 by 30-in. rolls to (9).
(9) Two Bartlett tables; concentrates to bin, tailings to (10).
(10) Eight settling tanks; settlings to (11).
(11) Nine Wilfley tables; concentrates to bin, tailing to waste.

The mill is lighted by a 165-light dynamo. The power for the mill is furnished by two Pelton wheels, 4-ft. and 6-ft. The 4-ft. wheel drives the dynamo and tables; the 6-ft. wheel runs the rolls and breaker. The mill is substantially built and cost upwards of $100,000. The water for power and mill use is taken from the Nelson tunnel, by means of a 3-ft. steel pipe 600 ft. long and a flume 2,000 ft. long to a penstock, whence it descends to the power pipe, 24 and 22 in. in diameter, 400 ft. long, with a head of 200 ft. The concentration is 6 into 1. The present capacity is 200 tons daily.

Milling Practice at Park City, Utah.—The system employed at the Daly-West mill[26] is as follows: Crusher to screens, rolls and jigs, which make five sizes of product; concentrates to bin. The tailings are ground in Huntington mills and then go to Wilfley tables. The concentrates go to bins and the middlings to another set of tables which make concentrates to bin. Tailings and all slimes and overflow are raised by centrifugal pumps to the Sherman settling and classifying tanks. There are six or seven of these tanks, each 12 ft. deep. The first is 3.5 feet in diameter. Each succeeding tank has such diameter that will give it double the capacity in gallons of the one before it. An open iron cylinder is suspended in each tank and into this the slimes to be settled are fed. The heavier particles settle in their downward movement, while the lighter ones rise outside the inner cylinder and overflow to the next tank. At the bottom of each tank (which converges to some extent) is an opening for discharging the settled slimes to Wilfley tables which make concentrates to bins. The middlings are pumped to the settling tank from whence they came. The tailings go to waste.

The concentrates run very uniformly and assay about as follows: Silver, 55 oz.; lead, 10 to 30%; iron, 12 to 14%; copper, up to 2%; zinc, 8 to 30%; gold, up to $1 per ton. The capacity of the mill is 225 to 240 tons per 24 hours. The iron and zinc in the small sizes are separated by magnet. The zinc shows 16 oz. silver per ton.

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26 *Mining Reporter*, Vol. LXVII, 1903, p. 490.

Concentrating Plant in Kootenay, B. C.—E. R. Woakes[27] writes on a modern coarse concentration plant for silver and lead ore in the Kootenay, B. C., district. The concentrator was designed to treat the ore from the Highland Mining Company's mine. The problem was to treat a large quantity at minimum cost by careful adaptation of machines. The ore is brought from the mine by an aerial rope tramway, 4,700 ft. long, operated by two men, and is dumped automatically into an ore bin from which it passes over a grizzly directly to a No. 3 Gates breaker, which discharges the crushed ore to a belt conveyor, which in turn discharges it into the hopper of the coarse rolls, 26 by 15 in., running 85 r.p.m. The product goes to a trommel with 7/8 in. holes. Undersize of trommel to elevator to series of sizing trommels; oversize to medium rolls of same size as first, running 95 r. p. m. The main trommels give the following sizes: 7/8, 11/16, 1/2, 1/4 in., 3 mm., 10-mesh.

The oversize of 7/8-in. trommel goes to a two-compartment Hartz jig; concentrates to bin, and tailings to medium rolls. Oversize of 11/16-in. trommel to a two-compartment Hartz jig; concentrates to bin, tailings to waste, middlings to medium rolls. Oversize of 1/2, 1/4 in., 3 mm. and 10-mesh trommels go to Hartz jigs; concentrates to bin, middlings to fine rolls running at 105 r. p. m., tailings to waste. Through 10-mesh goes to classifier; first and second spigots to Hartz jigs; concentrates to bin, middlings to fine rolls, tailings to waste. Third and fourth spigots to Wilfley tables; overflow to classifiers, making three spigots, to Wilfley tables. Overflow to spitzkasten making spigot to Wilfley table and overflow to waste. The Wilfley tables make concentrates to bin and tailings to waste.

The mill is operated entirely by water power. A 4-ft. Pelton wheel on the top floor is run with a head of 450 ft. and the water is caught in a tank and used in the mill. The tables, as well as the electric light plant, are operated by Peltons. The total cost of the plant complete was: Machinery and hardware, $16,693.05; freight and duty, $4,126.98; lumber, $3,590.66; wages and salaries, $11,555.07; total, $35,965.76. The cost of milling is 29c. per ton. The capacity is 180 tons per 24 hours. The saving is 81.5 per cent. of the lead. The average tailings assay was 0.6 oz. silver per ton. The feed carries 0.5 oz. silver per unit of lead.

Milling of Lead Ores in Mexico.—Mr. G. A. Burr[28] describes two notable concentrating plants in Mexico, that of the Montezuma Lead Company, treating 450 tons in 24 hours, and that of the Minas Tecolotes y Anexas, treating 400 tons per day. The ore of the Montezuma company averages as follows: Silver, 250 grams per ton; gold, 3 to 6 grams per ton; lead (as PbS) 6 to 10%, carrying 60% of the silver; zinc (as ZnS) 7 to 12%, carrying 5% of the silver; iron (as FeS_2) 6 to 7%, carrying 30% of the silver and all of the gold;

27 *Canadian Mining Review*, Vol. XXII, 1903, p. 11.
28 The Engineering and Mining Journal, Vol. LXXVI, 1903, p. 392 400.

copper (as Fe_2CuS_3) 0.5 to 1%; silica, 50%, carrying 5% of the silver. An extraction of 80 to 85% is made. The following system is employed:

(1) Grizzlies, bars 1.25 in. apart; undersize to (3), oversize to (2).
(2) Four 10 by 20-in. Blake breakers to (3).
(3) Four belt conveyers to (4).
(4) Two pair 15 by 40-in. Cornish rolls to (5).
(5) Trommels, ½-in. holes; oversize to (6), undersize to stock bins.
(6) Two pair 36 by 12-in. rolls to stock bins.

For further treatment of the ore there are two units, each having one stock bin.

(7) Stock bins to (8).
(8) Elevators to (9).
(9) Three trommels (9/16 to ½ in., ¼ to 9/16 in., ⅛ to ¼ in.) to (10).
(10) Pocket classifiers; spigot to (11), overflow to (15).
(11) Six double 4-compartment Hartz jigs; concentrates (65 per cent lead) to smelter, middlings to (12), tailings to (13).
(12) Rolls; product to (10).
(13) Seven 6-ft. Monadnock Chile mills to 40 mesh, to (14).
(14) Thirty-four Wilfley tables; concentrates to smelter, middlings to (16), tailings to waste, and slimes to (15).
(15) Eight Frue vanners.
(16) Magnetic separator; concentrates to smelter, tailings to (17).
(17) Three Wilfley tables; concentrates to smelter, tailings to waste.

The Minas Tacolotes y Anexas plant has a capacity of 400 tons per day. The values are much the same as in the Montezuma company's ore. The motive power is furnished by five 120-h. p. Otto gas engines. The tree of the process is as follows:

(1) Grizzly, 1 in. between bars; undersize to (2), oversize to (3).
(2) Belt conveyers to six 30 by 14-in. rolls; product to (5).
(3) Six Dodge breakers; product to (4).
(4) Belt conveyor to 24 by 16-in. rolls; product to (2).
(5) Trommels; over ⅛ in. to (2), under ⅛ in. to (6).
(6) First row of tables (15 Bartlett's); concentrates to smelter, middlings ground to 60 mesh and classified to (7), tailings to waste.
(7) Two rows of 15 Wilfley tables, yielding concentrates, middlings, tailings.

The concentrates are said to average 1,000 grams of silver, 30 to 32% lead, 9 grams gold and 8% zinc per metric ton. An extraction of 65 to 70% is secured. No slime-saving devices are used.

A Lead Ore Washing Plant.—Mr. W. H. Borlase[29] describes the lead ore washing plant at the Greenside mines, Patterdale. It consists of breaker and

29 *Transactions* of the Institution of Mining Engineers, Vol. XXV, 1903, p. 331.

rolls followed by trommels, classifiers, jigs and buddles. The sieve scale is 2.5, 3, 4, and 6 mesh to the linear inch, followed by spitzkasten with four boxes.

Milling in Upper Michigan.—C. F. Jackson[30] describes milling methods used in the copper district of Michigan. The stamp mills are usually placed on the side of a hill near the lake shore, so that waste sand and water can flow into the lake. The Calumet & Hecla mill has distributed sand over an area of 100 acres. The refuse sand amounts to 1,500,000 cu. yd. per year. The sand is elevated by a wheel, 65 ft. in diameter with a 10-ft. face, driven by a 750-h.p. motor. The steam stamps at the Calumet & Hecla have cylinders 20 in. in diameter and work at a steam pressure of 110 lb. The weight of a stamp complete is 6,000 lb. The stamps make 95 to 105 blows per minute. Stamp shoes used on conglomerate rock last about three days. On soft amygdaloid rock they last about three weeks. The cast iron anvil under the stamp mortar weighs from 90 to 120 tons. Concrete foundations for stamps are used at Baltic and Wolverine mills.

Milling Practice at Anaconda.—Martin Schwerin[31] writes on the method of concentrating at Anaconda. The ore is from the Anaconda group of mines, and contains pyrite, chalcocite, bornite, enargite, chalcopyrite and covellite. The gangue is quartz and granite. Two classes of ore are designated, (1) that rich enough to go direct to the smelter and (2) that which must go to the mill to be concentrated. The object is to concentrate the copper and iron. There are no harmful minerals as blende to remove. The mill makes fine and coarse concentrates. The fines are roasted in MacDougal furnaces, and the coarse goes direct to blast-furnace. The mill has two independent halves of four independent units each. All eight units are alike except in some minor details. The mill is built on a gentle sloping hillside. The following is the outline of one unit:

(1) A steel trestle brings 50-ton cars over bins. Each unit's bin holds 1,250 tons of ore or 48 hours supply. Each bin has two discharge gates operated by compressed air, to (2).

(2) Two shaking screens 1.25 in. round holes; oversize to (3); undersize by two elevators to (6).

(3) Blake breakers, 12 by 24 in., to (4).

(4) Two cast iron trommels, 1.25 in. round holes; oversize to (5), undersize by two elevators to (6).

(5) Blake breaker, 5 by 15 in., by elevators to (6).

(6) Two 7/8-in. round hole trommels; oversize to (10), undersize to (7).

(7) Two 7-mm. round hole trommels; oversize to (11), undersize to (8).

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30 *Journal* Western Society of Engineers, Vol. VIII, 1903, No. 1, p. 1.
31 The Engineering and Mining Journal, Vol. LXXVI, 1903, p. 388.

(8) Two 5-mm. round hole trommels; oversize to (18), undersize to (9).

(9) Two 2.5-mm. round hole trommels; oversize to (19), undersize to (20).

(10) Two Hartz jigs; hutch to (18), concentrates from screens to (16), tailings to (12).

(11) Four Hartz jigs; hutch to (18), concentrates from screens to (16), tailings to (13).

(12) Unwatering screens; oversize to (14), undersize to (18).

(13) Unwatering screens; oversize to (15), undersize to (18).

(14) Rolls; then by elevators to (6).

(15) Rolls; then by elevators to (6).

(16) Screw conveyor to (17).

(17) Coarse concentrates bin.

(18) Twelve Evans jigs, two sieves, tandem; hutch to concentrates bin, tailings to (23).

(19) Twelve Evans jigs, two sieves, tandem; hutch to concentrates bin, tailings to (23).

(20) Evans classifier; overflow to (33), spigot to (21).

(21) Evans classifier; overflow to (33), spigot to (22).

(22) Twelve Evans jigs; hutch to concentrates bin, tailings to (23).

(23) Unwatering tank; settlings to elevator to (25), overflow to (24).

(24) Settling tank; settlings to (37), overflow to smelter.

(25) Screen 1.5 mm.; oversize to (40), undersize to (41).

(26) Twelve Evans jigs, three sieves, tandem; hutch No. 1 and 2 to concentrates bin, hutch No. 3 to elevator to (28), tailings to (27).

(27) Settling tank; overflow to smelter, settlings to dump.

(28) Huntington mill to (29).

(29) Evans classifier; overflow to (37), spigot to (30).

(30) Evans classifier; overflow to (37), spigot to (31).

(31) Twelve Evans jigs, three sieves tandem; hutch No. 1 and 2 to concentrates bin, hutch No. 3 to elevator to (28), tails to (32).

(32) Settling tank; overflow to smelter, settlings to dump.

(33) Fourteen settling tanks; overflow to smelter, settlings from first three plugs to (35), from plugs No. 4 and 5 to (36).

(34) Settling tank; overflow to smelter, settlings first three plugs to (35), plugs No. 4 and 5 to (36).

(35 and 36) Seventeen Wilfley tables; concentrates to concentrates bin, middlings to (37), tailings to waste.

(37) Seven settling tanks; overflow to smelter, plugs No. 1, 2 and 3 to (38), plugs No. 4 and 5 to (39).

(38 and 39) Sixteen Wilfley tables; concentrates to concentrates bin, middlings to elevator to (37), tailings to dump.

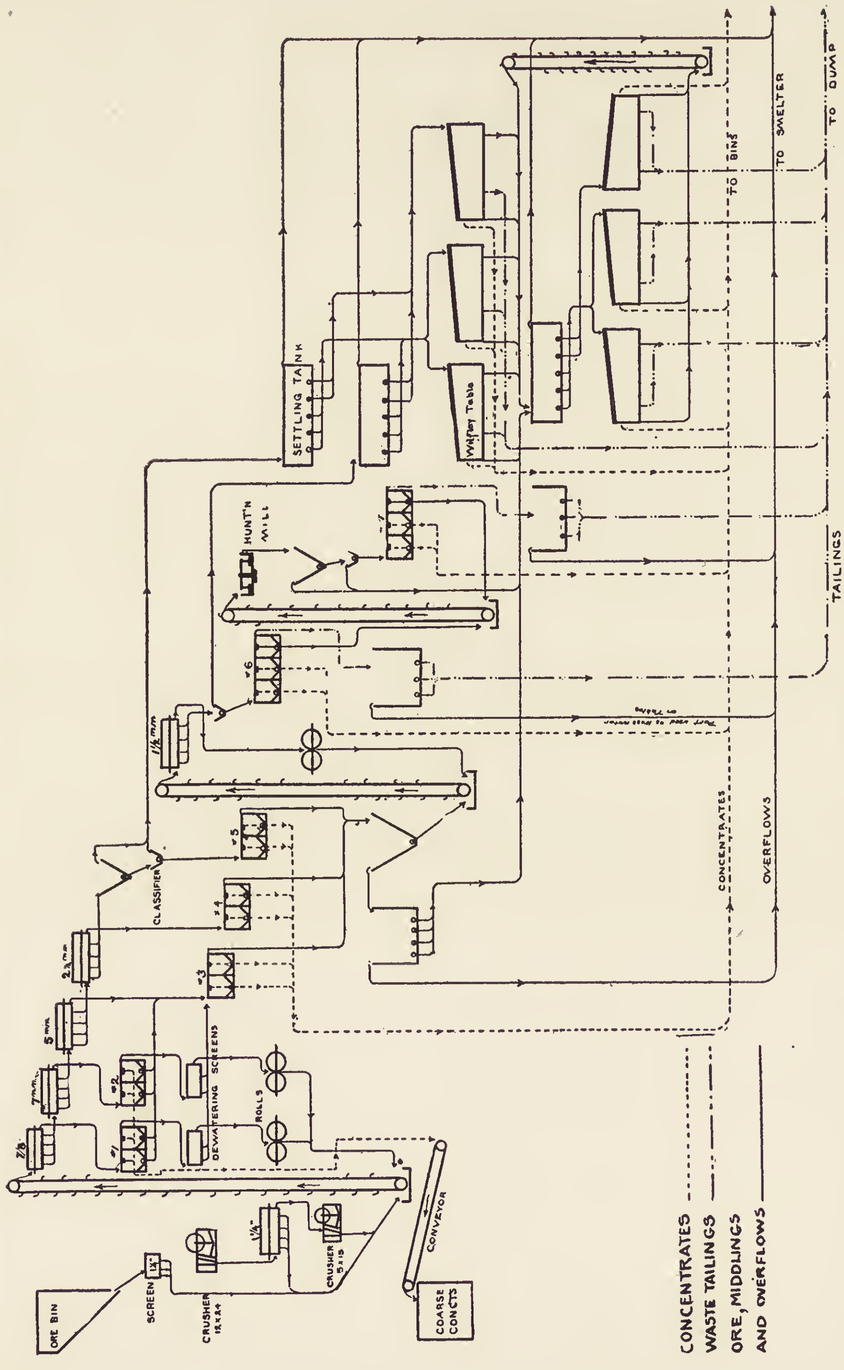

FIG. 1 DIAGRAM SHOWING METHOD OF CONCENTRATION AT ANACONDA.

(40) Rolls; to elevator to (25).

(41) Evans classifier to (26).

The overflows of the settling tanks, which go to the smelter, are there used for cooling purposes, etc.

The concentrates section is separate from the mill proper. There are nine settling bins to each unit, in three rows of three each, arranged so that the launders can discharge into any one or any two adjacent bins of the two outside rows. The overflow from these flows through any or all bins of inside row. Overflow from the inside bins of half the mill go to three large bins in the center of the building. The other half of the mill is the same, making 78 bins in all. The overflow from the six large center bins goes to flumes and to power house for condensing water. Mr. Schwerin thinks that there is too much re-handling of ore in the first part of the mill. Barren quartz getting on (10) would go to (14). Part of it would go to (11) and some to (18), (19), (20), and be again recrushed, and then to (26). This is a rehandling of rock to save the mineral in particles of rock almost barren. There seems apparently to be no remedy. In handling tailings from (18), (19), (20), sizes from 7 mm. from (18) are crushed to pass 1.5 mm. In the sizes of screens, 1.25 in. (32 mm.), 7/8 in. (22 mm.), 7 mm., 5 mm. and 2.5 mm., there is too big a gap between 22 and 7 mm., and too small a difference between 7 and 5 mm., while that between 32 and 22 mm., and 5 and 2.5 mm. need not be so small. Two sets of jigs could replace (18), (19) and (20). This could be accomplished by using trommels with 32, 16, 7 and 2-mm. holes. Closer sizing than this is not necessary.

Milling Practice at Cananea.—Martin Schwerin[32] describes concentrating at La Cananea. The designed capacity of the plant is 600 tons per day. The ore is from two distinct mines, the Capote and the Veta Grande. The ore from the Capote consists of coarse agglomerated crystals and finely divided crystals of pyrite in a much decomposed feldspathic gangue. The surface of the pyrite is covered with a thin film of chalcocite, and on breaking apart the cohering crystals the new faces as well as the faces of weakness and cleavage are all similarly coated. The fine crystals are most frequently found in vast aggregations of uniform particles in talcy nodules. The Veta Grande ore is soft chalcocite in irregular bunches and veinlets in a gangue of massive quartz. Native copper in papery branching sheets fills many interstices of the gangue. Some pyrite is present; a small amount of normally hard massive chalcocite occurs in both ores. The system employed at the mill (two units) is as follows:

(1) Two ore bins holding 18 hours supply deliver ore by hand gate and chute to (2).

(2) Two grizzlies, each taking ore from one bin; fixed inclined slots 1 in. wide; oversize to (3), undersize to (5).

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32 The Engineering and Mining Journal, Vol. LXXVI, 1903, p. 463.

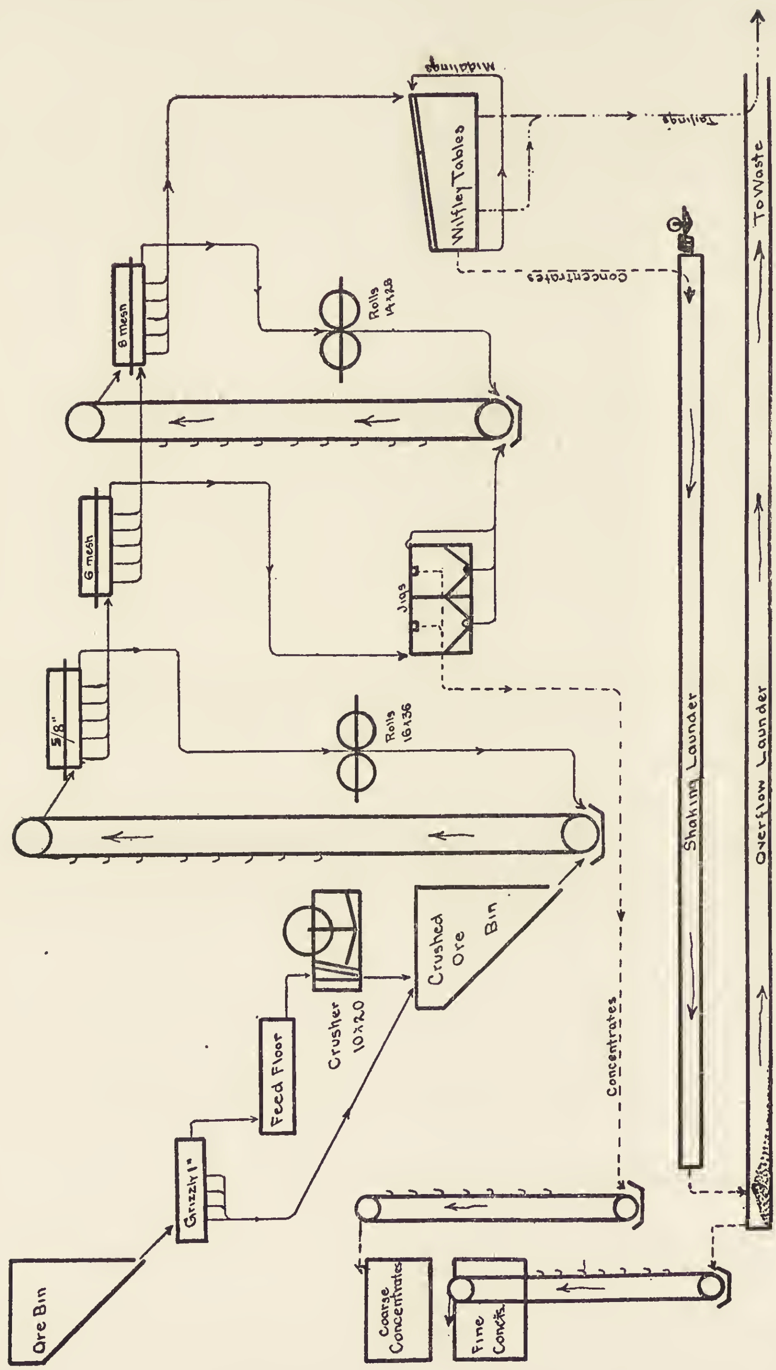

FIG. 2. DIAGRAM SHOWING METHOD OF CONCENTRATION AT CANANEA.

(3) Feeding floor for (4).
(4) Blake breaker, 10 by 20 in., crushing to 1 in.; ore fed by hand goes to (5).
(5) Crushed-ore bin by elevator to (6).
(6) Trommel 5/8 in.; oversize to (7), undersize to (8).
(7) Rolls, 16 by 36 in., by elevator to (6).
(8) Two trommels 3/8 in.; oversize to Hartz jigs of two sieves, tandem; undersize to (9).
(9) Two trommels 6 mesh; oversize to (10), undersize to (11).
(10) Hartz jig, two sieves, tandem; intermittent hutch discharge; hutch by elevator to (11), tailings by elevator to (11), concentrates by elevator to (17).
(11) Two 8-mesh trommels; oversize to (12), undersize to (13).
(12) Rolls, 14 by 26 in., by elevator to (11).
(13) Twenty-two Wilfley tables; middlings back over table, slimes and tailings to settling tank to waste, concentrates to (14).
(14) Shaking launder, to (15).
(15) Overflow launder; upper end for concentrates by elevator to (16).
(16) Fine concentrates bin.
(17) Coarse concentrates bins.

Mr. Schwerin thinks concentration should begin on coarser sizes, and the sieve scales should have more numbers in it, making middlings for recrushing, and so save the losses in fine slimes.

Mechanical Preparation and Concentration of Minerals.—A general article by H. Lenicque[33] gives a short description of ore dressing. Three sizes of minerals are given. Larger than 16 mm., from 16 mm. to 1/4 mm., and slimes less than 1/4 mm., with information as to the kinds of concentrators adapted to their treatment. Mention is made of the Elmore oil process and of the Wetherill concentrator for magnetic separation.

Separation of Zinc Blende.—An abstract from the *Australian Mining Standard*[34] describes a process for separating particles of blende from the waste material of the concentrating mills. The process in brief consists of feeding the material into a vat containing a solution of salt cake of a density of 14° B. and a temperature of 195° F. The acid generates gas from the blende which rises to the surface and may be floated off by addition of more solution, while the rest of the mineral remains on the bottom of the vat.

Ore Drying.—Drying by direct heat, as in rotary cylinder, is cheapest.[35] Care must be taken to have all iron parts designed to withstand stresses due to expansion and contraction. No cross seams should be employed. The

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33 *Comptes Rendues Mensuels*, June, 1903, p. 131.
34 *Mining and Scientific Press*, Vol. LXXXVI, 1903, p. 118.
35 The Engineering and Mining Journal, Vol. LXXVI, 1903, p. 622.

cost of drying depends on five factors: (1) The percentage of moisture in the mineral, (2) whether the mineral to be dried will permit of the passage of fire gases through it, (3) whether the mineral is sandy or clayey, (4) upon the ignition temperature of the mineral, (5) the degree of dryness to be attained. It is safe to assume an evaporation of 10 lb. of water per pound of coal burned with ore through which the products of combustion can be passed. Silicious ores are more easily dried than clayey ones. It is very hard to dry down to a moisture of 0.5 per cent and it is not often required.

Tin Dressing.

Ore Treatment at Mount Bischof, Tasmania.—Donald Clark outlines the Mount Bischof tin concentrating plant.[36] The system used is as follows:

(1) Stamps (896 lb.) with 14-mesh screen, stamping 4 tons per stamp per 24 hours; the pulp goes to (2).
(2) Spitzlutte, yielding spigot product to (3) and overflow to (4).
(3) Five No. 1 Hartz jigs, yielding concentrates to a bin, middlings to (5) and tailings to (6).
(4) Spitzkasten yielding first, second and third spigot products to (9), overflow is waste.
(5) Five No. 2 Hartz jigs yielding concentrates to bin, middlings to (8) and tailings to (6).
(6) Five buddles yielding concentrates to (7) and tailings to waste.
(7) Chilean mill; product to (8).
(8) Five slime tables yielding concentrates to (9) and tailings to waste.
(9) Five Kayser ore-dressing tables, yielding concentrates to (10), tailings to waste.
(10) Dolly tub, concentrates to bin.

Tin Concentration in Cornwall.—C. M. Myrick[37] describes at length the old Cornwall system of tin concentration, using stamps and buddles. He states that Frue vanners have been introduced to take the place of the buddles in some plants. They save room and recover 90% of the tin in one operation, making a concentrate suitable for the calciner.

A Cornwall Plant.—Mr. Edward Skewes[38] outlines the separation of iron sulphide, wolframite and cassiterite by the magnet at the Tamar river, between Cornwall and Devon. Concentrates of Buss tables and Luhrig vanners are roasted in Bruckner cylinders. They then yield the iron sulphide by magnetic machine with four amperes. The wolframite is next taken out by magnet with 12 amperes, leaving the cassiterite behind. The capacity of the magnet is 5 tons per day.

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36 *Australian Mining Standard*, Vol. XXIX, 1903, p. 432.
37 *Mining and Scientific Press*, Vol. LXXXVI, 1903, p. 167.
38 The Engineering and Mining Journal, Vol. LXXVI, 1903, p. 424.

Oil Concentration.

The Elmore Process.—McDermott[39] reports in regard to silver-lead ores that the oil process has not been much used. As on copper ores, the saving depends on the condition of the surface of the particles; tarnished or oxidized ore is not suitable. He finds that the process can be carried out in a cleanly manner, but that the cleanliness depends on the design and management.

At Tywarnhaile, Wales, a 10-stamp mill is at work with a two-unit oil plant (50 tons per day) treating old dumps of quartz and slate that contain iron and copper pyrites assaying only 0.6% copper. They make concentrates assaying 8% copper with an average extraction of 80% of the assay value. The labor required is one man and two boys per eight-hour shift. The loss of oil depends chiefly on the relative proportion of concentrates, which carry away 3 to 6% of the oil.

In regard to the process McDermott states that there are three essential points on which the success of the operation depends. They are, (*a*), the nature of the oil used, (*b*), the method of application to the crushed ore, and (*c*), the separation of the absorbed mineral from the oil.

(*a*) The thick residuum of petroleum gives best results. American residuum has a specific gravity of 0.88. Some thick oils from the East with specific gravity 0.86 were found to be good. The specific gravity is very important, as the oil has to absorb the mineral and still float on the water. The more viscous the oil is the better for catching the ore, and the less viscous it is the better for separation from the concentrates. The viscosity can be regulated by the addition of thicker or thinner oils and also by the temperature of working. The action of the oil can be stimulated by addition of acids (for example, sulphuric or hydrochloric acid), presumably, to clean off the tarnish. Very thin mill pulp is best treated by thick oil.

(*b*) The oil is best brought in contact with the ore by the action of slowly revolving cylinders, provided with a helical launder and low baffle plates. This gives sufficient agitation, causes no breaking up of the oil and gives clean concentrates. The oil is separated from the gangue in a pointed box, the latter drawn from the bottom, the former from the top.

(*c*) The ore and oil are floated over the side of the box through a heater to increase liquidity, and then to a centrifugal pan of 48 in. diameter, with an inward flange at the top, revolving 1,000 times per minute. This centrifugal pan separates the oil from the ore. Hot water is first charged so as to form a vertical wall of water, and the heated oil and concentrates are fed into the bottom; the oil floats inside the wall of water, while the concentrates pass outward through the water and pack on the side, to be removed periodically. The concentrates carry 3 to 6 % of oil.

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39 The Engineering and Mining Journal, Vol. LXXV, 1903, pp. 113, 262, 292.

The Elmore Plant, London, England.—The process as employed in the Elmore plant at London[40] is as follows:

(1) Stone breaker to (2).

(2) Huntington mill to (3).

(3) First revolving cylindrical mixer, yielding heavy pulp with crust of oil and ore to (4), and light pulp to (5).

(4) Pointed box settler yields oil and values to (7), water and sand waste.

(5) Second revolving cylindrical mixer, yielding heavy pulp to (4), light pulp to (6).

(6) Third revolving cylindrical mixer, yielding heavy pulp to (4), light pulp to (8).

(7) First centrifugal separator yields concentrates to market, oil to (9).

(8) Large settling tank yields oil and ore, water and sand waste.

(9) Second centrifugal separator yields concentrates, oil to cooling store tank.

A note[41] is given on a plant of two 100-ton units of Van Meter-Boss oil concentrators, at Carahuacra mine, Victoria, Peru.

Magnetic Concentration.

Various Systems of Concentration.—In a somewhat lengthy article[42] describing various magnetic concentrators in Sweden several systems are considered of which three are here reproduced. At the Svarto mill the treatment is as follows:

(1) Blake breaker crushing to 60 or 70 mm. to (2).

(2) Rolls crushing to 40 mm. to (3).

(3) Rolls crushing to 2 mm. to (4).

(4) Monarch magnetic separator, yielding concentrates, middlings to (5) and tailings.

(5) Monarch separator, yielding concentrates, middlings and tailings.

All dust is caught and treated by magnetic separator. All tailings are concentrated wet into apatite and waste. The weights and composition of the various products of the magnetic work are:

	Tons.	Fe %	P %
Crude ore	82,811	58.	1.0
No. 1 concentrates	59,146	70.	.127
No. 2 concentrates	11,923	60.	.75
Non-magnetic	11,020	25.51	13.70 (P_2O_5)
Dust	833	28.88	8.70 (P_2O_5)
Loss	482	.....	.....

40 The Engineer, Vol. XCV, 1902, p. 216.

41 *Mining and Scientific Press*, Vol. LXXXVII, 1903, p. 304.

42 *Jernkontorets Annalen*, 1903, p. 251.

At the Klacker Serberg mill the system used is as follows:

(1) Blake breaker to (2).
(2) Rolls to (3).
(3) Gröndal magnetic separator, yielding concentrates, and tailings to (4).
(4) Gröndal separator, yielding concentrates and tailings.

At the Romne mill the following system is employed:

(1) Gates breaker to (2).
(2) Rolls to (3).
(3) Gröndal magnetic separator, yielding concentrates to (4) and tailings.
(4) Gröndal separator, yielding concentrates to (5) and tailings to (2).
(5) Screen 0.2 mm. mesh; oversize to (2), undersize to market.

Concentration at Mineville.—The magnetic treatment at Mineville, N. Y., is well described.[43] Two grades of ore are mined; 'old bed' which is high in phosphorus, and 'new bed' low in phosphorus; each is treated in its own mill. The mills being alike, one only is described. The system used is as follows:

(1) Blake breaker, 30 by 18 in., 250 r. p. m., crushes to cubes of 1.5 to 2-in. to (2).
(2) Revolving screen, with holes 0.75 in., yielding oversize to (3), undersize to (4).
(3) Blake breaker, 36 by 6 in., 225 r.p.m., crushes to 0.75 in., goes by elevator to (2).
(4) Revolving screen, 6-mesh, yielding oversize to (5) and undersize to (6).
(5) Reliance rolls, 36 by 14 in., 100 r. p. m., to (6).
(6) An Edison drying tower in which the ore descends and the hot gases rise through baffle plates to (7).
(7) Tower screen, Edison type, with 288 sq. ft. of screening surface, divided into four equal sections of 30, 16, 10 and 6-mesh screens, yielding oversize to (8) and the other four products to separate bins feeding magnetic separators (9).
(8) Reliance rolls, 36 by 14 in., by elevator to tower screen (7).
(9) Four magnetic concentrators; one Rowand magnetic machine, type F, for 6 to 10 mesh; one Rowand magnetic machine for 10 to 16 mesh; one Ball Norton magnetic machine for 16 to 30 mesh; one Ball Norton magnetic machine for 30 mesh to fines. They yield concentrates to (10) and tailings to (11).
(10) Bins for concentrates.
(11) Tower screens, 20 and 16 mesh, with 72 sq. ft. of surface, yielding over 16 mesh to (12) and through 16 to 20 mesh to (13) and through 20 mesh to dust to (13).

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43 *Iron Age*, Vol. LXXII, December 17, 1902, p. 10.

(12) One Wenstrom magnetic separator which makes concentrates to (10) and tailings to (14).

(13) Two Wetherill, type E, magnetic separators, which yield concentrates to (10), middlings (mainly hornblende) to waste, and tailings of apatite and quartz, to phosphate market.

(14) Reliance rolls, 36 by 14 in., to (11).

The mill treating 'old bed' ore gives the following results per 20-hour day:

	Tons.	Fe %	P %	Bone Phosphate %
Crude ore	800	59.59	1.74	.....
Iron concentrates	680	67.34	0.675	.....
No. 1 apatite	60	3.55	12.71	63.05
No. 2 apatite	60	12.14	8.06	40.30

The mill treating Harmony or 'new bed' ore gives the following results per 20 hours:

	Tons.	Fe %	P %
Crude ore	600	50.26	0.295
Iron concentrates	462	64.1	0.133
Tailings.	138	13.97	0.877

A New Jersey Plant.—At the Hibernia mine in New Jersey magnetite is concentrated in the following manner:[44]

(1) Through a 16 by 24 in. Buchanan breaker, 225 r. p. m., to (2).

(2) Revolving screens, with 2.5-in. holes, oversize to (3), undersize to (4).

(3) Buchanan corrugated rolls, 36 by 18 in., 126 r. p. m., to (2).

(4) No. 1 Ball magnetic separator of lower magnetic potential—13—and higher speed of revolution—25—which yields coarse finished concentrates to (5) and unfinished to (6).

(5) Delivery bin.

(6) No. 2 Ball separator of 25 magnetic potential, 13 r. p. m., yields clean rock to (7), lean ore to (8).

(7) Sizing screens which grade it into useful sizes.

(8) Buchanan rolls, 120 r. p. m., to (9).

(9) No. 3 Ball separator with 15 potential, and 25 r. p. m., yielding fine ore to (5) and fine rock to (7).

The average content of the materials in iron is: Crude ore, 47.6%; coarse concentrates, 58.2%; fine concentrates, 54.61%; tailings, 23.55%. The hornblende carries 6 to 8% iron, which brings up the iron in the tailings. The advantage claimed is the concentrating of coarse sizes avoiding necessity for briquetting.

44 *Iron Age*, Vol. LXXII, October 22, 1903, p. 16.

Concentration in Sweden.—In a paper by Arpâd Zsigmondy[45] a description is given of the occurrence and mining of the Swedish iron ores, including notes on magnetic concentration.

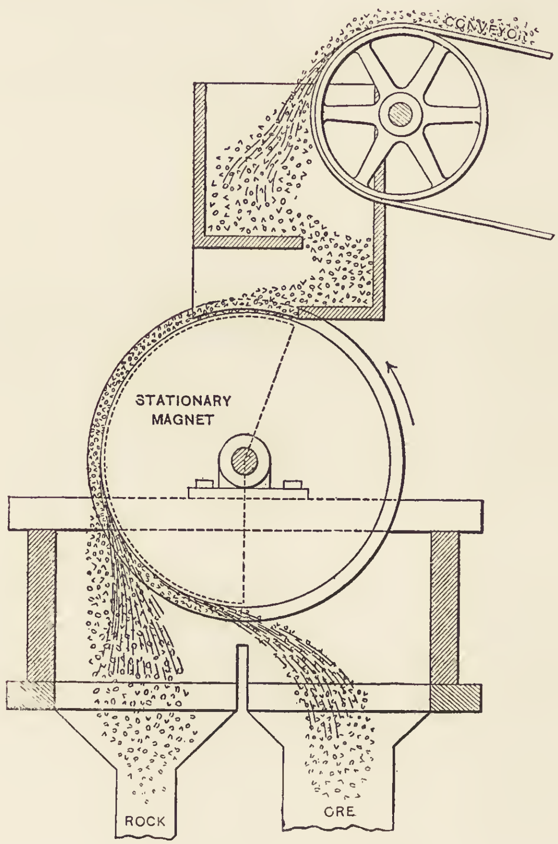

FIG. 3. BALL MAGNETIC SEPARATOR.

K. G. Brunnberg[46] gives an account of progress in concentrating Swedish ores by magnetic means. Some comparative results are shown below:

Concentrator.	Size of Ore. mm.	Crude Ore. Fe %	Concentrates Fe %	Tailings. Fe %
Gröndal	1—0	25.1	60.5	12.0
Fröding	1—0	31.3	57.8	10.7
Forsgren	0.5—0	35.7	60.1	10.4
Eriksson	0.2—0	36.5	62.5	9.8

At Herrang the Fröding ore separator[47] has displaced a Monarch separator and yields a waste residue that is 8% poorer in iron. About 20,000 tons of

45 *Oesterreichische Zeitschrift*, Vol. LI, 1903, p. 279.
46 *Journal* of the Iron and Steel Institute, Vol. LXIII, p. 548.
47 *Oesterreichische Zeitschrift*, Vol. L, 1902, p. 560.

waste are produced annually, and the yearly gain through the change amounts to 2,400 tons of concentrates, with 67% iron.

The Broken Hill Plant.—In the plant at Broken Hill, Australia, the material treated is a tailings product containing lead, zinc and iron sulphides carrying silver[48]. By separation a magnetic product containing 40 to 48% zinc, and 10 to 12 oz. silver per ton, and a non-magnetic product containing 10 to 12 oz. silver and 12 to 17% lead are obtained. The electric energy required per ton of ore is 1,000 watts. There are five of these separators, each with a capacity of 32 tons per 24 hours. The magnetic machine has a revolving cylindrical pole with screw-thread surface. The ore fed to this pole is attracted by it and carried out of the field of greatest magnetic intensity, where it drops off or is brushed off.

Magnetic Separation of Zinc Ores.—Mr. S. W. Osgood[49] writes that the concentration by the magnet has reached a high state of efficiency in separating iron from zinc ores, but that the great problem lies in the treatment of the fines. He finds that 23.9% of the zinc contents in the ore treated is in the portion that will pass through 150-mesh, and that the mineral unaffected by the magnet increases in per cent as the size diminishes.

Dings Magnetic Separator.—A magnetic separator made by the Dings Electro-Magnetic Separator Company, of Milwaukee, claims to treat 2,000 lb. per hour.[50] The machine is 66 in. high, occupies 36 by 48 in. floor space, and weighs 1,200 lb. The power required is one ampere at 110 volts and 0.5 h. p. for mechanical drive. Conveying belts are not used in operating the machine.

Joplin Jack Table.—The Joplin[51] jack table is a magnetic machine for separating mundic (iron sulphide) from zinc ore. It has a capacity of 15 to 20 tons per day (10 hours).

Blake-Morscher Separator.—Mr. W. G. Swart[52] writes in regard to the Blake-Morscher static electrical separator that the machine was patented in February, 1901, and that mineral particles dropped upon a statically charged metallic pole-piece are charged with electricity and violently repelled at a rate varying with their conductivity; that most of the sulphides are the best conductors and therefore fly off quickest; that sulphide of zinc is an exception to this rule, and this gives a means of separating iron sulphide from zinc sulphide. A voltage of 250,000 was used at first, but it has been reduced to from 10,000 to 20,000 volts, which gives good results. The latest machine treats 10 to 15 tons in 24 hours, and sizes ranging from 6 mesh to 200 mesh with slight variation of construction or adjustment. Sizing helps, but close sizing is not needed. About 20 mesh gives the best results. The standard machine is 24 ft. long, 41 in. wide, 81 in. high and uses about 1 h. p. On Joplin

48 *The Australian Mining Standard*, Vol. XXVIII, 1903, p. 265.
49 The Engineering and Mining Journal, Vol. LXXVI, 1903, p. 349.
50 *Iron Trade Review*, Vol. XXXVI, 1903, p. 64.
51 *American Manufacturer and Iron World*, Vol. LXXIII 1903, p. 550.
52 The Engineering and Mining Journal Vol. LXXV 1903, p. 146.

jig concentrates, of which 43.97% were coarser than 20-mesh, and 56.92% finer than 20-mesh, fed to separator without sizing or roasting, at the rate of 16.11 tons per 24 hours, the following products are obtained:

	Crude Concentrates.	Iron Concentrates.	Clean Zinc Sulphide.
Zn %	49.20	3.60	60.69
Fe %	9.62	39.24	2.02
Pb %	8.89	8.89	Trace
SiO_2%	4.60	5.00	3.10

The iron concentrates were 18.22% of total, the zinc sulphide 80.21% of total.

Coal Washing.

A French Coal Washery.—The Luhrig and Coppée coal-washing plant at Monchy, France,[53] uses the following system for treating 40 tons crude coal per hour:

(1) Trommel screen yielding oversize and undersize.
(2) Four jigs for the oversize.
(3) Classifier or spitzkasten for the undersize.
(4) Six jigs for washing the fines.
(5) Three tanks, one for the washed coal, one for the washed coal dust, one for the waste.

A Montana Coal Washery.—J. V. Schaefer[54] describes the washing of coal by the Montana Coal & Coke Company at Aldridge. The structure of the coal is such that hand picking is impossible. The fire clay is the chief obstacle. The plant consists of a bin feeder, a breaker to ½ in., two classifier boxes and two feldspar jigs. The cleaned coal from these is run on 8-mesh copper wire screens to free it from fire clay, then sluiced to the coke ovens with clean water. The undersize which passes through the draining screens goes by elevator to re-washing jigs. The middlings go to the boilers for power and heat. The waste goes into the lake.

	Mine Yield. Per Cent.	Ash. Per Cent.
Coking coal	61.	10. to 11.
Middlings fuel	3.	18. to 20.
Rejected waste	36.	60. to 68.

Control of Coal-Washing Machines.—M. Pierre Charoet[55] writes on the control of coal-washing machines by a study of graphic curves made by laboratory experiments. The article is a long one, giving the machines used, the results obtained, and the curves and conclusions obtained from them.

Stewart System of Coal Washing.—D. T. Blakey[56] describes the Stewart system of coal washing, with illustrations. It consists briefly of rolls, ele-

53 *Le Genie Civil*, Vol. XLIII, June 13, 1903, p. 112.
54 *Mines and Minerals*, Vol. XXIV, 1903, p. 228.
55 *Bulletin* Société de l'Industrie Minérale, Vol. II, 1903, part 2, p. 335.
56 *Mines and Minerals*, Vol. XXIV, 1903, p. 212.

vator, bin and jig. The relative quantities and specific gravities of the minerals to be separated and the products recovered are shown in the following table:

	Crude Coal. %	Average Sp. G.	Washed Product.	Tailings. %
Coal	82.6	1.33	87.9	3.8
Bone coal	11.4	1.45	10.3	18.2
Shale	4.5	1.60	1.8	78.9
Slate from partings	1.5	1.95	0.0	

Washing Culm.—G. W. Harris[57] describes the washing of the old dumps at the Bellevue colliery, Scranton, Pa. The slack is flushed by 2.5-in. firehose into a scraper conveyor and conveyed to boot of main elevator, thence to the top of the washery. It is first treated on the upper shaking screens with three sieves, 2.75 in., 1.5 in. and 7/8 in. On 2.75 in. classed as grate coal and hand picked for slate and bone; through 2.75 in. but on 1.5 in., classed as egg and stove coal, cleaned by Emery picker; through 1.5, but on 7/8 in., chestnut, cleaned by Christ jig. All these cleaned coals are sent to market, or if the market demands small sizes they are crushed and go back to boot of main elevator. What passes through 7/8 in. goes to lower shaking screen, with four screens 5/8, 3/8, 1/4 and 3/32 in., and yields the following products: Through 7/8 on 5/8 in., pea, cleaned by Christ jig; through 5/8 on 3/8 in., buckwheat No. 1, to bins direct; through 3/8 on 1/4 in., buckwheat No. 2, to bins direct; through 1/4 on 3/32 in., buckwheat No. 3, to bins direct; through 3/32 in. to old workings for filling.

The total consumption of water is 1,000 gal. per minute. A 95-h. p. engine runs the plant. The output is 1,000 tons per day. The saving is 75%, the waste 25%. The force consists of 32 men outside and 8 men inside.

Coal Screening.—A gyrating screen Kreiselratter for screening coal is described and illustrated.[58] The screens are rectangular and placed one above the other, mounted in a single frame. They are given a gyrating motion by eccentrics on vertical shafts on either side of the screen frame. The capacity is from 200 to 1,200 tons in 10 hours, and requires 2 to 4 h. p. to operate it.

A list of papers on coal screening is given, in the Iron and Steel Institute *Transactions,*[59] which will be of interest to men working in this line.

Aultman Coal Conveyor.—The Aultman new coal conveyor[60] is constructed of two strands of heavy drop forged steel chain with steel flights of 1/4-in. steel attached at stated intervals to give the required capacity. The conveyor travels in a trough made of 1/4-in. steel plate. It can be driven by steam, electricity or compressed air. It can be made of any length up to 1,500 ft. and can have a capacity up to 4,000 tons in 10 hours. When running at 60 ft. per minute it makes little noise and does not break the coal.

57 *Mines and Minerals*, Vol. XXIII, 1903, p. 481.
58 *Oesterreichische Zeitschrift*, Vol. LI, 1903, p. 57.
59 *Transactions* of the Iron and Steel Institute, Vol. LXIII, 1903, p. 609.
60 The Engineering and Mining Journal, Vol. LXXVI, 1903, p. 778.

THE MINING INDUSTRY IN ALASKA.*

BY ALFRED H. BROOKS.

The value of the gold output of Alaska for 1903 was approximately $8,600,000. Of this output the placer gold forms about seven-eighths, and is increasing much faster than the yield from lode mining. The other mineral products of Alaska are as yet of small importance, silver ranking first, with an annual output of $60,000 to $100,000 in coining value. A few thousand dollars' worth of copper is produced, but only incidental to prospecting and development, few of the copper mines having as yet installed their mining equipment. It is not generally known that Alaska contains some excellent coal; but this is only mined for local consumption, and the entire output does not exceed 4,000 to 5,000 tons per annum. The year 1903 witnessed the exportation from Alaska of a little stream tin and a small quantity of petroleum. The stone industry is represented by one marble quarry, near the north end of Prince of Wales island, which, as far as known, has not yet shipped any building stone.

During the past year the ever active prospector has extended the knowledge of the distribution of placer gold by the discovery of the Fairbanks district on the Tanana, the Good Hope district in the northwestern part of the Seward peninsula (both of which give promise of important commercial development), and the Kobuk district (of which less is known) in the upper basin of the river of the same name. Of far greater importance, though they have received less notice in periodic literature, are the new discoveries and steady developments made in the older districts, for it is to these that the larger part of the mineral output is due. The introduction of mining machinery and improved methods has been general throughout Alaska wherever transportation facilities exist.

Southeastern Alaska.—The pan-handle, or southeastern Alaska, as it is called, so far promises the most important lode mining. An even climate, accessibility, timber, and ample water power make this region particularly favorable to economic operations. The public has been slow to appreciate this fact, for unless undeceived by personal experience it still regards Alaska as the land of ice and snow, of the Esquimaux and fur-trader.

Juneau Region.—Juneau is still the focal point of the productive mines in this region, though other towns promise vigorous competition. Before the discovery of the Klondike this field was rapidly developing, but it received a decided check when the first tidal wave of popular excitement carried the

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mining men into the interior, and later to Nome. Now Juneau is recovering its former position of importance. Many properties, including some of the largest, have changed hands during 1903, and a score or more of competent engineers and mining experts have been in the field making examinations and estimates. While no new mining plants have actually been installed, plans have been formulated for large investment of this character. Able men, backed by ample capital, are at the head of these enterprises, which carry no element of 'boom' and are mostly planned after careful and exhaustive study. It is reported that the Alaska Treadwell Gold Mining Company has begun work on a two-mile tunnel, which is to start at 600 ft. above tidewater near Juneau and tap the Silver Bow basin, where the company controls extensive property; and that the Perseverance Mining Company, which also holds important interests in the basin, is planning to attain the same end by a trolley line to tidewater. It is the intention of both companies to place their mills near tidewater, so as to avoid the snowslides which interfere with work in the basin during some of the winter months.

In the ceaseless roar of the great mills of the Treadwell, the mining public sometimes loses sight of the fact that this does not cover all of southeastern Alaska. While it is by all odds still the great enterprise of this region, several others are producing and many more give promise of doing so. In the mainland belt, extending from Endicott Arm northwestward along the coast and including Sum Dum, Snettisham, Juneau, Salmon creek, Eagle river, Berner's bay and Seward, many prospects are being developed and a number of important producing mines are being worked. Placer mines are being exploited at half-a-dozen localities. In the islands to the westward mining operations are going on at Rodman bay, where a large plant is being installed, and Silver bay, where less important developments are in hand.

Porcupine District.—It would be impossible to enumerate all of the localities in this region where the miner and prospector have been active. Attention should be called, however, to the Porcupine placer district, which lies in the Klehini and Salmon river valleys, both tributary to the Chilkat, and 15 to 20 miles distant from tidewater. The development of this district has been retarded by the boundary dispute, for the provisional line of the *modus vivendi* of 1899 ran almost through its middle. The deposits of Porcupine creek are of such character that they require the investment of large capital for their exploitation. On the creek itself there seems to be room for a strong company. In spite of the serious drawbacks to its exploitation, the district has gone on developing and producing ever since its discovery in 1898.

Ketchikan District.—The formations of southeastern Alaska trend northwest-southeast, parallel to the coast line, preserving a more or less persistent lithologic character; and as certain of these formations have proved to carry bodies of ore, other mineral deposits, as would be expected, have been found throughout the belt. The Ketchikan district, lying adjacent to Dixon entrance on the south and including portions of the mainland as well as Prince of

Wales, Gravina, Revillagigedo and a number of smaller islands, is second only to the Juneau region in importance. Conditions have changed materially during the past three years, in which more rational and systematic methods of prospecting and exploitation have been introduced. At present there are several gold and copper properties which are being worked at a profit, though still in a small way; and investigations looking toward the establishment of large mining plants are going on in a score of places. In some of these the installation of machinery is now under way, while in others the work is still being directed toward determining the extent of the ore-bodies.

The copper ores are prevailingly chalcopyrite and bornite, and another class of deposits, which have been found in a few localities, show large exposures of bornite and azurite at the surface. All of these ores usually carry gold. The gold-bearing lodes thus far successfully worked have been small though persistent quartz veins, carrying high values in free gold. Larger deposits of free gold are not absent, however, but none have been successfully exploited. This does not mean that such undertakings will not meet with commercial success, for the attempts that have been made were ill-advised, reaping the failure which is apt to result from building a mill before the approximate extent of the ore-bodies has been proved. The natural advantages of the Ketchikan district will probably make it possible to exploit lower grade ore-bodies than can be worked with profit in most parts of the world.

On the west side of Prince of Wales island operations are being pushed at several localities on copper properties which it can be conservatively said show excellent surface indications, though they have not been tested to any considerable depth. The Alaska Copper Company, on Copper Harbor, in order to reach an ore-body which outcrops in extensive ledges of copper carbonate at the crest line, 3,000 ft. above tidewater, is driving an adit which is expected to cut the ore-body 1,500 ft. below the surface workings. A smelter is also under construction.

At the Mamie mine on the Kasaan peninsula, in the eastern part of Prince of Wales island, a large body of chalcopyrite ore is reported to be opened up to a depth of 100 ft. or more. A smelter is in course of erection by the same company that is opening the mine. The Mt. Andrew, an adjacent property where considerable development work has been done, is unfortunately tied up by a lawsuit.

Other developments too numerous to mention are going on throughout the Ketchikan district. It should be noted that several small stamp-mills are being built. A second ore-bearing zone has been found east of the great belt of coast range granite, which was long believed to mark the eastern line of possible commercial importance, and gold lodes with accompanying placers have been found on the Unuk river, which flows into Behm canal, and on Salmon river, which empties into Portland canal. Some of these prospects lie close to the newly determined boundary line, the early location of which is essential to their development.

Central and Southwestern Alaska.—West of Cross sound the Pacific coastal belt holds little of interest to the placer miner. Some gold has been found in the beach placers of Lituya and Yakutat bays, which have been and are being exploited spasmodically in a small way. More important is the alleged discovery of placers in the valley of the Yakataga river, but the reports as to their extent and value as yet lack confirmation.

Prince William Sound.—This deep indentation of the coast line west of the Copper river delta has long been known as a region of chalcopyrite deposits. These have been located and some small developments made, but in few cases has the work gone to sufficient depth to prove their extent. These lodes, like those of southeastern Alaska, are favorably situated with reference to water transportation, and the region yields some timber; but the climate is much colder than that of the southern districts. At the Gladhaugh mine a small plant has been established and work has been going on for the past few years. During 1903 the region has been subjected to an examination by a number of competent mining experts, and more extensive development is expected.

Copper River Region.—The Chistochina placer district continues to be worked, but the distribution of gold-bearing gravels is not sufficiently wide to promise a material increase in the present output, of $200,000 to $300,000 per year. The fact that it is 200 miles distant by trail from tidewater materially increases operating expenses. There are rumors of important discoveries lying to the west of the Chistochina basin, probably on streams draining into the Sushitna. It seems quite possible that the conditions which gave rise to the Chistochina placers may recur at other localities in the region and that its full resources have not yet been proved.

The placers of the Niszena river, tributary to the Chittena, an eastern fork of the Copper, are frequently mentioned in periodic literature, but are not known to be actually productive. The copper deposits of the Copper river are receiving some attention from mining men, though there seems to have been but little attempt at a systematic investigation of individual lodes. The surface indications are such as to warrant an expenditure of money in exploration. The ores, chiefly chalcopyrite and bornite, with some native copper, occur in a well-defined zone near the contact of white limestone and greenstone which follows the southern slope of the Wrangle mountains, about 200 miles distant by trail from tidewater. For the purpose of exploiting these deposits a railway will have to be constructed across the Chugach mountains at an altitude of about 2,800 ft. On the north side of the Wrangle mountains, in the drainage basins of the Tanana and White rivers, is a second belt of copper-bearing rocks which has been but little prospected.

Cook Inlet Placer Fields.—Gravels carrying gold in paying quantity have long been known on some of the streams which are tributary to the upper end of Cook Inlet. This district, known as the Turnagain Arm or Sunrise district, has shown a steady development during the past three years; its accessibility, long open season and abundance of timber making it possible to exploit placers of relatively low grade. Efforts during the past year have been directed toward erecting hydraulic plants, several of which are now at work.

On the Kenai peninsula, south of the above district, a hydraulic equipment has been installed at Tustumena lake to work a large body of low-grade gravel. Another company has erected a thirty-stamp mill to work a free-gold quartz ledge near Aurora, on Kachemak bay, an eastern arm of Cook Inlet.

Seward Peninsula.—At least six-sevenths of all the placer gold of Alaska comes from the Seward peninsula, whose output of $5,000,000 or $6,000,000, it is safe to say, has far from reached its maximum. The total tonnage of vessels to the Seward peninsula during the season of 1903 aggregated 96,822. While some of the older creeks of this region have been nearly stripped, placer mining in the peninsula, as a whole, is but fairly begun. The introduction of better methods has entirely changed the character of operations. Placers which under the old conditions could not be touched, can now with the aid of hydraulic methods, steam hoists and shovels, etc., be made to yield a handsome profit. While it is improbable that any creek gravels yielding less than $2 or $3 per cu. yd. have been mined at a profit, there is no doubt that ground of a much lower grade will prove profitable in the near future. The placer gold of the Seward peninsula is remarkable for wide distribution and variety of occurrence. Beside the creek and gulch gravels, which with the beach deposits have thus far produced most of the gold, there are the bench placers, the high benches, the old beaches and the gravel plain placers. The last mentioned have only recently received attention, and there is no reason to believe that the limit of discoveries has been reached.

Among the general developments in the peninsula during the past season are the improvement in landing facilities at Nome (still, however, a difficult problem), the building of railway and roads, and the extension of the telephone system. The Wild Goose narrow-gauge railway, extending from Nome to Anvil, has done much to facilitate the handling of mine machinery. The Solomon & Council City railway, now under construction, will not only afford good transportation facilities to its terminal, an important camp, but will give access to some important districts which lie adjacent to its route. The construction of petroleum tanks at Nome, connected with Anvil creek by a pipe line, gives promise of cheaper fuel. The building of a number of ditches to bring water to the placer mines is, by all odds, the most important feature of the recent developments. The Miocene ditch and others have been in use for the past two years, and several are in process of construction. Among the largest of these are those planned to tap the great reservoirs of water found in the glacial-scoured amphitheaters and valleys of the Kigluaik mountains, some 40 miles north of Nome. As it has been definitely established that these ditches can be constructed and maintained at reasonable cost, considering the price of wages, which are $4 to $5 a day, it is cheaper to employ ditches than to secure water by pumping, at the present high cost of fuel.

The Nome district is probably more advanced in mining methods than any other of the peninsula. Water is furnished by the Miocene ditch at the rate of 2,000 to 3,000 inches, and in smaller quantities by others as well as by two large pumping plants, the Kelly on Nome river and one owned by the Wild Goose Mining Company on Snake river. Several hydraulic lifts and other labor-saving machinery have been introduced. While the bed of Anvil creek has been entirely washed out, the benches are being actively exploited. It was one of these that yielded the $3,000 nugget, the largest that has been found in Alaska. The high beach deposits between Dexter and Anvil creeks are being mined by underground methods. Many shafts have been sunk to a depth of 50 to 200 ft. through the frozen gravel until the pay-streak is reached, and then this is followed by drifting. These plants all use steam hoists and work both summer and winter. The tundra or gravel-plain placers at Nome have been extensively prospected with the aid of churn drills. Some mining has been done with steam shovels and bucket dredges along the creeks which traverse these gravels; but the best method of mining these low-lying placers, which are unquestionably of great extent, has not yet been ascertained, though several strongly-backed companies are working toward that end.

In the Solomon river region the construction of the railway is to be considered the most important event of 1903. On Big Hurrah creek a small quartz mine, the only one in the peninsula, is being successfully operated. It is equipped with a ten-stamp mill run by a Pelton wheel in summer and a gas engine in winter, and sufficient ore of a free-milling character is in sight to make it a paying investment. Two steam shovels were used on the bars of Solomon river during the past season.

The Ophir creek district is second only to Nome in importance as a gold producer, the equipment of its placer mines including three hydraulic lifts, several inclines, derricks, etc. A large steam shovel has been in operation on the Niukluk river and is reported to be a success. The camp is connected with navigable waters of the Fish river by a short railway.

The other districts of the peninsula deserve only passing mention. At Topcock there was completed last summer a 12-mile ditch which will furnish the water to hydraulic a large deposit of rich gravels. In the Bluestone district, where a 2-mile ditch is used to furnish water, the most important recent discovery is the finding of gold on a bench 100 ft. above the present water level. The streams tributary to the north side of Grantley harbor have been known to carry gold-bearing gravels, and a ditch is now being planned to work these deposits, which are not of high grade. The Kugerock district, because of its isolation, is the slowest of development. Many of its placers are a hundred miles or more from tidewater by the usual routes of travel, a fact which materially increases the cost of production. Work is still going on at Dahl and Harris creeks, and steps have been taken toward other developments.

The northeastern part of the Seward peninsula was the scene of considerable excitement during 1903, but work has not as yet been on an extensive scale. The shovel, pick and rocker still reign supreme, though the accessibility of the district from the Arctic Ocean and the richness and extent of some of the placers will soon lead to the use of better methods. Candle creek, discovered some two years ago, is still the chief producer, but its bed is being rapidly exhausted and more attention is being turned to the benches. An eastern extension of this district is found in the gold-bearing gravels of Bear creek, which flows into Buckland river. The most important discoveries of this field are the placers of the Immachuck, a river which has a length of 20 to 30 miles and flows through a broad flood plain. The gravels are from six to eight feet deep, and in many cases have been found to carry good values. Though the developments of the past year have been chiefly of a preliminary character, considerable gold has been mined.

Some mention is due the tin deposits which are being developed in the York region at the western end of the peninsula. The stream tin, discovered in 1900, is being exploited in a small way, and 30 to 40 tons are said to have been shipped during the past summer. Besides the localities which are being mined, stream tin has been found at a number of other places, but its commercial value remains to be proved. Noteworthy is the finding of cassiterite in bed-rock on Lost river. The ore is disseminated through a granitic dike which cuts a crystalline limestone of Silurian age.

The Yukon Basin.—Gold is widely distributed through the gravels of the Yukon basin, but aside from the discovery of the Fairbanks placers, there have been no important developments during 1903. As the deposits are, for the most part, remote from water transportation, there are scores, if not hundreds, of creeks whose gravels cannot be profitably exploited until better transport is available. The crying need of the region is for wagon roads, and it would be a great boon if funds could be raised by some form of taxation, preferably by changing the law so that a part of the assessment work required on placer claims could be commuted to a money tax; but there is small hope of effecting this unless Alaska's present bizarre civil administration is changed into some form of representative government.

All of the placer districts of the Yukon have shown a healthy growth during the past year. The high rate of wages, from $5 to $8 a day, with board, has led to the introduction of mining machinery and improved methods wherever conditions of transport and extent of deposits would permit. The men who have established these mining enterprises are worthy of the highest praise, for they have often worked in the face of the most adverse conditions. After a placer has been located and its commercial value proved, it usually takes a whole year to select the equipment and to ship it by water to the nearest point. The following winter the heavy material is carried to the claim by sleds, and the succeeding summer is required to install it. It is therefore two or three years before the miner can hope to have any return from his investment, which, as he usually has little capital, is apt to be a great hardship.

The Forty-mile district, which is the oldest in the Yukon basin, is still producing about $200,000 annually, and promises to increase its output. The old expensive hand work is being replaced by horse and steam scrapers and hoists. Of prime importance is the finding of gold on Chicken creek in benches 200 to 300 ft. above the present stream level. Similar benches on other creeks have not yet been prospected, but it is reasonable to expect that they, too, may carry gold in paying quantity.

One large hydraulic plant has been installed on American creek and two on Seventy-mile river, but none of these has been operated. The history of the Birch creek diggings is much the same as that of the Forty-mile region. Benches are being worked where creek beds have been exhausted. In the Rampart region two small hydraulic plants have been put to work, and others are in course of erection. The Baker creek region has as yet developed no rich deposits except those of Glenn gulch, which is already nearly exhausted. There are, however, a number of streams in the district where mining is going on in a small way. The Fairbanks district of the Lower Tanana has already been referred to as promising important discoveries, but very few developments have been made.

The reports from the Koyukuk region have been very favorable, the product being estimated at $200,000 to $300,000. This, the most remote mining district of Alaska, lying far north of the Arctic circle, can be reached only by an overland trip of 200 miles, or by a steamer and small boat journey of 400 to 600 miles. The high cost of supplies and labor has made the net profit exceedingly small.

Coal and Petroleum.—The question of fuel supply is an all-important one to the mining interest. In the timbered areas of the Yukon and in part of the Pacific coastal belt the demand for fuel has been met by the local wood supply, but in the timberless areas, such as the Seward peninsula, coal or petroleum has been imported at large expense. The Mesozoic and Tertiary beds of the Yukon carry workable coal-seams of a fair semi-bituminous and lignitic character. Some prospecting has been done, and one or two mines are equipped for supplying the river steamers with fuel, but operations have gone on only in a small way. The introduction of petroleum-burning fire-boxes on the steamers of the Northern Commercial Company has, for a time, somewhat checked the industry.

At Cape Lisbourne, on the Arctic Ocean, workable coal-seams of a good semi-bituminous character have long been known, and have offered an emergency fuel supply for both whalers and revenue cutters. More systematic attempts at mining, to supply the Nome market, 200 miles away, have not yet met with commercial success. Some little work was done at this locality last season, but practically no coal was shipped, the chief difficulty being the lack of harbor or proper shipping facilities. Coal has been found at various points in the Alaskan peninsula, but it has been mined only in a small way during the past season. The extensive coal-mining plant at Homer, on Katchemak bay, does not seem to have been in operation during 1903. Of considerable importance is the discovery at Comptroller bay, east of the Copper river delta, of commercial coal, which is known to occur in large quantities, and is of the highest grade yet found on the Pacific coast. It lies from 20 to 30 miles inland, and lack of a proper harbor will make the transhipment difficult.

The petroleum deposits of Alaska have been rather more widely advertised than their present development would seem to warrant. Drilling operations have been carried on at three general localities near Comptroller bay, in what is variously known as the Kayak or Katella oil field; at Eneshin bay on Cook Inlet; and at Cold bay on the east side of the Alaskan peninsula. It is of interest to note that important oil seepages occur at all three of these localities, and that the bed-rock of all three belongs to the same horizon. While the indications seem to be favorable, at only one well, situated in the Comptroller bay region, has there been any flow of oil.

MINING IN ARIZONA.

BY WILLIAM P. BLAKE.

The output of gold for 1903 was materially lessened by the closing down of the King of Arizona, by the continued idleness of the Mammoth, and the diminishing production of the Fortuna.

The passage of the eight-hour law by the last legislature of Arizona is regarded by many as a repression of industry and a serious blow to mining. The opening of new lines of railway now gives access and transportation to many important mining districts, especially those along the route of the road under construction from Phœnix to Florence and beyond, along the Gila and San Pedro to Benson.

In this great region of many mountain ranges we do not find a concentration of lodes in one main range, as in California, but a more general distribution, with a greater variety of form and mineral association. As a general rule, there is a larger degree of intermixture with the sulphides of iron, lead and copper in the lodes of Arizona than in those of the Mesozoic slates of California. The persistence of this belt of slates along the western slope of the Sierra Nevada, from Mariposa northward, gives approximately the same lithologic conditions of wall-rock and lode formations through many counties, while in Arizona the uplifts are more numerous and the strata range in geologic age from the Cambrian to the Quarternary, with many plutonic intrusions, and having many rather than one single dominant axis of uplift and plication.

The Fortuna, in Yuma county, has been worked through an incline shaft to a depth of 1,500 ft. One shaft was lost by caving early in 1903. The ore has been high-grade, ranging in value from $20 to $30, and even $50 per ton. The total production of this mine, since its opening, probably has been not less than $3,000,000. During the year the production has been steadily decreasing, owing to the loss of the main oreshoot by complex faulting. Lower-grade ores have been worked, and even the large dump of waste, in which there was some good ore, has been passed through the mill. But exploration underground has been maintained at a large cost, and unless success attends these efforts the Fortuna may be regarded as practically worked out. The Gold King, in the same county, is now in operation, but was idle most of the year 1903. The workings have reached a depth of 300 ft. or more, and the promise is good for much greater depths. An accident to one of the wells from which water was obtained retarded operations for a time.

The Congress mine, in Yavapai county, has increased its production. The total depth reached by the incline shaft is 3,800 ft. on the dip of the ledge.

Two other approximately parallel veins have been found by cross-cutting. In the month of March, 1903, a new mill of 40 stamps was added, and now 80 stamps are dropping, about 300 tons being put through daily. The ore is pyritic, and is first roasted, then cyanided.

The numerous gold-bearing veins in the Bradshaw mountains, south and east of Prescott, have been prospected with high promise and success in several instances. The Crowned King mine has been closed by litigation. The Oro Belle, on Humbug creek, has been in successful operation. There has been great activity in the development of gold-bearing lodes in the region of Wickenburg and of Rich Hill, including the quartz claim formerly worked by Johnson. The Leviathan is also under development. The Vulture has been under investigation, with a view to re-opening and working it to greater depths. The Mammoth and contiguous gold mines at Shultz, in Pinal county, are still idle, but with a prospect of being reopened and worked.

The Gold Mountain prospect, in the Galiuro mountains, of which so much was expected in 1902, has been found to be too low grade, taken in mass, to be worked with profit, and has remained idle. The gold is confined to the little quartz veinlets and the cavities left by the decay of iron pyrite.

The Arivaca and Oro Blanco districts, in Pima and Santa Cruz counties, south of Tucson, have experienced a substantial revival of mining. The properties, known as Tres Amigos and the Sorrel Top, both gold mines of great extent and promise, but long idle, have changed ownership and are now being re-opened and equipped with mills. The Old Glory has also been re-opened and worked. The Oceanic is now one of the important gold mines of the Arivaca district. The ore is said to average $10 per ton and to yield about 40 per cent of this on plates, the remainder being suitable for cyaniding. The McDonald group is in slate near the Old Glory mine; the ore has been subjected to a working test by taking 50 tons over to the mill of the Montana company, where water is obtained from the Cheney reservoir, and working it there by stamping and amalgamation. The Montana mine, upon a large vein of galena and zinc-blende, remains unworked, the cost of transportation being too great to permit of the ore being sent to the El Paso smelter.

The Pride of the West, that large establishment for the separation of pyrite, galena and zinc-blende, with the production of copper matte, closed down early in 1903, and has remained idle since. Tentative shipments of zinc-blende concentrates were not followed up.

At Washington Camp nothing of importance has been accomplished during 1903, and the mines are practically idle.

The World's Fair mine, which yields very rich argentiferous galena and copper sulphide, is situated near Patagonia, and is opened and worked at intervals by its owners, Mr. and Mrs. Frank Powers, who have made one or more shipments of high-grade ore to El Paso. This property was sold, in part, early in the summer of 1904, Mr. Powers, it is said, retaining a quarter interest.

In the Salero and Tyndall districts there has been considerable prospecting during the year, and shipments have been made from Patagonia (Santa Cruz county) and from the Eureka-Mabel mine at Salero. The ore of this mine consists of a mixture of gray copper, galena and native silver in a gangue of quartz and manganese spar. It occurs in a regular well-formed vertical vein in diorite, and has been opened in ore for over 150 feet. The Arizona Gold & Copper Company erected a small concentrating plant, consisting of Davis rolls and concentrating tables, near the Salero mines, but it is not in continuous operation.

The Sierra de Oro gold properties are situated along the San Francisco river, a few miles above Clifton, in Graham county, and cover a group of gold-bearing quartz-veins traversing granite. These are opened by an adit about 500 ft. above the level of the river and from 600 to 1,000 ft. below the outcrops of the ledges. When these ledges are intersected, drifts will be run each way on the ore, and a mill will be erected on the banks of the San Francisco river, which is less than a mile distant.

At Twin Buttes, Pima county, bodies of high-grade chalcopyrite with bornite have been found by sinking deeper on the Copper Glance and the Morgan claims. This has greatly stimulated and encouraged the desire to secure greater depth at the Helvetia and other claims.

In the Quijotoa district, the Weldon Gold & Copper Company has made the principal development during 1903; shafts have been sunk and other exploratory work has been carried out. The undertaking is backed by capital from Marquette, Michigan.

The placer deposits of Horseshoe basin have been worked in a desultory way by the Papago Indians, who make fair wages by dry-washing.

The old Liberty Clark mine, from which regular shipments of argentiferous galena have been made for years, and which was closed down upon the death of Mr. Clark, has been re-opened and worked under the direction of Mrs. May Clark, and several shipments of high-grade silver-lead have been made.

In the Tombstone district work has continued actively during the year. The mines of this camp are reputed to have yielded over $30,000,000 in gold and silver. This was taken out between the croppings and water-level. The consolidation of interests in one organization—the Tombstone Consolidated Mines Company, Ltd.—now permits of working these properties as a unit and the removal of the sea of water which for twenty years has prevented deeper mining. During 1903 the water was lowered 100 ft. below the 600-ft. level of the Contention, giving access to bodies of ore which, it is expected, will be fully equal in value to those formerly exploited above water. Pumps of great power and capacity have been installed at the 700-ft. level of the new shaft, and they have been in full operation since January, 1904. The water has been lowered enough to permit of running a long cross-drift west to connect with a winze which has been sunk from the 600-ft. level. Shipments of some two car-loads of ore are reported daily from the mine. Some very rich gold-ore has been found. The unwatering of the main Contention lode is accompanied by a lowering of the water-level in the surrounding mines, especially in the shafts on the West Side lode and as far west as the Lucky Cuss, thus showing an underground connection of these mines. The large dumps of second and third-grade ore, consisting largely of limestone and of oxides of manganese and of iron, at the Lucky Cuss are being shipped away to the El Paso smelter. Such shipments of low-grade fluxing ores have been rendered possible by the completion of the branch railway from Fairbank to the mines.

The Commonwealth Mining & Milling Company has been in continuous operation until recently. The lode has been opened to a depth of 527 ft. on the incline, or 102 ft. below the water-level. The ore at this depth is exactly like that above the water; it has not become more refractory, as was rather expected. Some unusually large stopes, 60 ft. wide in places, have been opened up in ore of fairly uniform grade. The mill of 80 stamps has been well supplied and the output of bullion has been satisfactory. Indication of caving in of the old stopes early in 1904 induced the general manager, Mr. John Brockman, to suspend extraction for a time until the ground had thoroughly settled. A new commodious shaft has been started by which access will be secured to the mine below the caved-in area. Crude petroleum is used under the boilers, and is delivered by rail from Cochise station on the Southern Pacific railway, 17 miles distant. There are reports of the discovery of a lode of ore similar to that of the Commonwealth in one of the hills eastward.

At the Poland mine the milling of ores has been discontinued pending the completion of the long adit, which should cut several lodes and add largely to the ore reserves.

The mines of the Castle Dome district, in Yuma county, have not been actively worked. The ore is a very high quality of argentiferous galena, making a pure, soft lead. It is shipped down the river Colorado from Castle Dome landing to Yuma, and thence by rail to the Selby works, near San Francisco.

Iron Ores and Coal.—There are many localities in Arizona where specular iron ore occurs in veins or beds. Magnetite is also found, and often in close association with copper ores. The many reports of the discovery of coal in quantity have not been well sustained by investigation. The supposed true Carboniferous coal of the San Carlos strip, at least that portion near the valley of the San Pedro, proves upon careful investigation by the U. S. Geological Survey to be of Cretaceous age, cropping in close proximity to a blue limestone holding undoubted Carboniferous fossils.

There have been several periods of excitement in Arizona over reported discoveries of petroleum in different parts of the territory, but there is not, as yet, any well-authenticated report of its occurrence in commercial quantities.

CALIFORNIA.

BY CHARLES G. YALE.

California is now producing from its mines and quarries over $35,000,000 annually, and increasing this output at the rate of $2,000,000 yearly. This may be considered a very good showing indeed from a State where it was supposed that upon the exhaustion of the gold placers the mining industry would become of small importance. While the gold-bearing gravels are by no means worked out, they no longer produce as much as formerly by the old methods, but other branches of mining have come to the front and largely make up the loss entailed through partial exhaustion of the placers. In fact, through the rapid development of the dredging industry larger amounts are coming yearly from the gravels. It is predicted that within a few years the annual yield from the dredges will equal, if not exceed, that from the drift and hydraulic mines combined.

In 1852 California produced in gold alone the sum of $81,294,700, and up to 1866 the annual yield was never under $17,000,000. In 1889 the product was only $11,212,913. Since then the yield of gold has gradually increased, until now, and for several years past, it has been about $17,000,000. This does not include silver, copper, petroleum, borax, quicksilver or any other mineral substance.

At present some 44 mineral substances are being utilized, and their relative standing is as follows: Gold, petroleum, copper, borax, clays and their products, quicksilver and silver, in the order named. The metals naturally lead, but large increases are apparent each year in structural materials, hydrocarbons, gases and non-metallic substances generally.

The metals or ores now produced include gold, silver, mineral paint, pyrites, quicksilver, copper, lead, manganese, platinum and chromite. The non-metallic substances are borax, coal, chrysophrase, mineral waters, salt, asbestos, infusorial earth, gypsum, magnesite, lithia mica, fullers earth, quartz, crystals, mica, soda, tourmaline and turquoise.

The hydrocarbons and gases include petroleum, asphalt, bituminous rock and natural gas. The structural materials are brick and pottery clays, portland cement, lime and limestone, macadam, rubble and concrete rock, paving blocks, marble, granite, sandstone, serpentine, slate and glass sand. Very rapid increase is being made in the annual value of some of the above, notably borax, quicksilver, copper and petroleum.

Though gold mining has been carried on in California since 1848, there is now coming annually from the quartz mines about 350,000 oz. a year more than there was 15 years ago. Gold is being produced in 35 counties, and the older districts still maintain their lead. Nevada county, where the first quartz mill in California was erected, is still first, with better prospect of an annual increase than of a decrease, largely because capital has been carefully invested there, and the quartz mines are well developed and equipped. Experience has proved that the veins 'go to the deep' and carry as good ore at 3,000 ft. as they did near the surface. These results have had the effect of encouraging others to sink deeper and to extend explorations with vigor. Moreover, much larger mills are now in use than formerly, and the number of stamps is constantly increasing.

The quartz mines of the State now show the largest aggregate of yield each year. Out of the $17,500,000 of gold and silver produced, over $13,000,000 is derived from the quartz lodes. The hydraulic mines come next, with about $1,200,000, the drift mines yield about $900,000 and the dredging operations about $800,000. The rest is from surface placers, including bar, river-bed, gulch, etc.

The rank of California counties in gold production is as follows: Nevada, Calaveras, Tuolumne, Amador, Kern, Butte, Siskiyou, Shasta, Placer, Trinity, Mariposa, Mono, Sacramento, San Bernardino, Plumas, San Diego, El Dorado, Sierra, Yuba, Inyo, Humboldt, Fresno, Riverside, Madera, Lassen, Tulare, Alpine, Los Angeles, Monterey, Del Norte, San Luis Obispo, Ventura, Colusa, Orange and Santa Barbara. The first two named are each yielding over $2,000,000 annually and the next four over $1,000,000 each. Altogether there are over 22,000 men employed in the gold, silver and copper mines of the State at present.

It was expected that the gold and silver yield of the State for 1903 would exceed that of 1902, but this did not prove to be the case. The production was influenced to a considerable extent by two factors not originally taken into account. One of these was the lack of water in the fall months, which caused many large quartz mines and nearly all the gravel mines to close for a period, and the other was the prevalence of labor strikes in certain districts, which caused the mines to shut down.

The ditches began to run dry in certain counties early in the fall, shutting off both water and electric power for mines and mills, and reducing the number of stamps, dropping or stopping them all until the advent of the winter rains. Only those mines with auxiliary steam-plants were able to keep a full force of men at work. Naturally, the gravel miners suffered most and had to quit altogether, with the exception of the drift mines and dredging claims; but some of the large quartz properties were idle for two months or more.

The strike of the miners in Shasta and Kern counties did the most harm, but similar conditions prevailed to a lesser degree in Tuolumne, Amador, El Dorado and Calaveras along the Mother-lode. Local unions have been formed by the Western Federation of Miners, and trouble has come where there was no trouble before. Generally speaking, it has not been a fight for increase of wages, as regular union rates prevail; but it has been more a fight for recognition of the union and for the reinstatement of discharged men. The miners would take away the right of the owners to discharge union men, except with consent of the union, while the owners contend for their right to judge the capacity of any miner; in other words, they will not pay full wages for incompetent men who belong to a union, nor will they be compelled to employ a union man they find unsatisfactory. These differences have caused the closing down of a number of prominent producing mines, and the end is not yet.

Development in gold dredging continues and is the principal feature of improvement in the gold mining industry. At Oroville, Butte county, there are now some twenty-seven machines at work, and dredges are working successfully in several other districts. Large tracts of land lying too deep for surface work, with insufficient fall for hydraulicking and too poor for drifting, can be worked profitably by dredges. Especially near Marysville, Yuba county, is there much development of this class of land. At one point, where some 2,400 acres in one tract have been acquired, two large dredges have been at work recently, each costing about $100,000. Tests of the ground lead the owners to believe that some $17,000,000 lie hidden in that and neighboring tracts. The ground itself has been heretofore considered valueless. In other places, orchard, vineyard and farming land has been purchased to be mined by this method, and dredging is now going on in Butte, Calaveras, Shasta, Trinity, Sacramento and Yuba counties. Dredging requires large investments in land and machinery, so that only strong companies undertake it. Some available dredging lands are now being sold as high as $3,000 per acre, but the average price of good ground of this character may be said to be about $800 an acre. Around Oroville the average yield per cubic yard is 27 cents, and the cost of working averages 7 cents.

Some gold is derived from the copper smelters, particularly in Shasta county, but also from Calaveras, Fresno, San Bernardino and Tuolumne counties. The smelters buy the quartz from the miners for fluxing purposes, paying on assay value. In this way some hundreds of small mines are enabled to run at a profit.

The capacity of the milling plants of many mines has been increased of late, and there are now a number of mills having over 100 stamps, where formerly a 40-stamp mill was considered large. Shafts are being sunk deeper than formerly, and there is a general willingness to sink 1,000 ft. or more at once. In one district there are six shafts over 2,000 ft. deep and one nearly 3,000 ft. Of course this deep sinking requires a good equipment of machinery, and is costly.

There is an apparent demand in California for 'going' gold mines, but less tendency to start development on prospects, so that the miners or discoverers have to do more work than formerly in order to close sales.

There is nothing especially new to be recorded in the mining situation for

1903 in California. Speculation in mining shares was light. Very few of the mines are listed on the stock exchanges or dealt in by the public generally, gold mining has become a business venture, like manufacturing. It is no longer the custom to put incompetent men in charge simply because they are relations or friends of directors; the superintendents are chosen for their fitness and experience. There is closer economy than formerly, and little or nothing is heard of extravagance, except in isolated cases where managers and directors are either unskilled or dishonest.

California is a very large State, covering 158,360 square miles. From the northwest and to the southeast corner the distance is 775 miles. The State is 148 miles across at the narrowest point and 235 miles at the widest. There are mountain ranges with peaks over 14,000 ft., and also valleys several hundred feet *below* sea-level. In so vast an area, with such diverse characteristics, it is natural to find a wide variety of mineral products. Greater attention is now paid to minor minerals; the great difficulty to contend with is usually the great distance of these deposits from market and the high freight rates still prevailing, which shut them from the centers of population in the East. It is for this reason alone that so many deposits of valuable mineral still lie untouched and undeveloped.

Nothing at all is being done with the iron ores, and it is only of late that much has been done with copper. Just at present there is a demand for quicksilver mines, and many new ones have been opened and brought to a producing stage in the past year. The output, however, exceeds the domestic demand, and much of the metal is exported and sold in competition with quicksilver from Spain and Austria for much less than home prices. The price of the metal has fallen somewhat of late.

The quarrying interests of the State are becoming more important, owing to the improvement in the character of buildings erected in the larger cities of the Coast. Very much more sandstone and granite is being used. A comparatively new feature is the gem mining, carried on mainly in San Diego and San Bernardino counties, but also in Tulare. Tourmaline is the principal gem, but a product is also made of chrysophrase, turquoise and kunzite.

COLORADO.

BY FORBES RICKARD.

No marked change in mining conditions in Colorado is to be noted for the year 1903. Statistics show a falling off in the output as compared with the previous year, which is to be expected in view of the plague of labor troubles which has been visited upon the State. The Cripple Creek and Telluride districts have been the main sufferers, and their mines are operating to-day under military protection. The Idaho Springs district has had its experience, and applied a remedy in no uncertain way.

Beyond general mine development work and an increase of mining facilities, comparatively little new work has been done throughout the State. A flurry of excitement came with the new camps of Bowerman (Gunnison county) and Sherrod (Lake county), but neither of these new finds has proved important.

Cripple Creek.—It is impossible to review mining in the Cripple Creek district for the year without reference to a succession of strikes in metal mine, mill, smelter and coal mine; and the combination of any two of such difficulties would easily account for the falling off in its production and dividends.

The most important work of the year was the starting and completing of the drainage 'tunnel,' or adit. The connection between the portal and El Paso 600-ft. level was made September 6, and from that time until November 26 the water-level of the district sank 11 feet. After November 25 the flow increased, and about the middle of December the water was receding at the rate of 6 in. per day, or 15 ft. each month. The drainage tunnel has proved conclusively that all the mines of the district, except those of the east side, are connected by water channels. By the east side is meant the Isabella, Vindicator and Golden Cycle mines. The water gauge in the Gold Coin mine shows that the mines of Battle mountain will be affected as much as any of the other mines. This adit has cost between $80,000 and $90,000. As it was costing about $10,000 per vertical foot of depth to unwater the mines by pumping, it is readily seen that the adit has more than paid for itself. The eventual result will be to lower the water-level of the district 230 feet.

The only discovery of any note for the year was that of the Old Gold on Beacon hill, which proved to be the extension of the main vein of the El Paso, C. K. & N. Company. Shipments from this ore-body are averaging better than 2 oz. gold per ton.

The famous Independence mine continues to produce at the rate of 200 tons daily of low-grade ore. It is likely to maintain this output through the year 1904, and longer. This mine can show a record production reaching the creditable figure of $11,000,000 since its acquisition by the Stratton's Independence, Limited.

Leadville.—This district has shown much activity during the year 1903, and is putting out a big tonnage. Through extensive mill construction and the use of improved milling methods, Leadville is successfully coping with the low-grade problem, and shipments show an increase over last year.

This year's output has averaged about 50,000 tons monthly, of which the Colorado plants of the American Smelting & Refining Company have handled about 36,000 tons, divided among oxidized manganese-iron ore 15,000 tons, sulphide 13,000 tons and 8,000 tons of silicious oxides. The Salida independent smelter of the Ohio & Colorado Smelting Company has taken care of about 5,000 tons of Leadville's production. The balance, or 9,000 tons remaining, consists of zinc ores and concentrates shipped to foreign points.

The new life taken on by some of the old mines on Fryer hill toward the close of 1902, has continued to be an interesting feature. In this part of Leadville there have been developed some enormous bodies of very clean sulphide ores, and good bodies of silicious oxidized ores; also some lead ore and silicious sulphides.

A new ore-body has been opened up in the Diamond mine in Big Evans gulch, which rewards the owners for their energetic persistence and money expended in dead work. The ore of this discovery is low-grade, but it carries 8 to 10 per cent iron excess, which makes it more marketable than it otherwise would be; and in this mine there occurs a streak of lead-carbonate ore carrying fair silver values.

The Yak tunnel has developed a 60-ft. ore-body of clean iron sulphide ore, and is making monthly shipments of 1,500 to 2,000 tons. Good shipments have been made during the year from the Ibex group on Breece hill.

The Fortune, which adjoins the New Monarch, is opening an immense body of ore. The oxidized ores of the surface workings pass into silicious iron sulphides as depth is gained, which is, of course, typical of a great many of Leadville's mines.

The downtown mines have been producing a large quantity of iron ore and holding up well. The Iron-Silver Company produces from 300 to 350 tons per day, divided between iron-copper sulphide and zinc sulphides.

The mills of the A. Y. & M. and A. M. W. are doing clean work and turning out a good quantity of concentrates. The A. Y. & M. is producing monthly about 1,000 tons iron-lead concentrates and as much more zinc concentrates, besides some 2,000 tons of crude ore. The A. M. W. is making a mill product of 400 tons of lead ore and 900 to 1,000 tons of zinc concentrates.

Aspen.—The camp of Aspen is producing monthly 9,000 tons to 10,000 tons of silver ore of a grade ranging from $8 to $20 per ton. The production totals $1,570,000, exclusive of mill yield. These ores are high in lime, and carry some lead. The main productive properties are those of the Percy LaSalle and the Durant companies. The Smuggler and Cowenhoven tunnel properties are doing their share. The output of the LaSalle Company's mines reaches 2,500 to 3,000 tons monthly. The Smuggler is now putting out about 1,000 tons monthly, but has been shipping more extensively. Some of the workings of this mine have been on fire for a long while.

Creede.—Shipments from Creede amount to 150 tons of crude ore daily. The Big Kanawha Leasing Company, which has been hindered of late by lack of coal, will add to the production about 30 tons daily in lead and zinc concentrates.

Silverton.—Silverton is doing very well. This camp is shipping monthly 3,000 tons. The principal producers are the Silver Lake and Sunnyside Extension. Recent developments in the Silver Lake property are reported to be very satisfactory. There has been opened up in this mine a very good grade of concentrating ore, and the mill product is of a better grade and quality than it has been in the history of the new ownership. The Gold King mine is said to be developing most satisfactorily. An important discovery has been reported from the North Star mine on Sultan mountain, just behind the town of Silverton.

Telluride.—Uncertainty of labor conditions during 1903 has retarded development in this district, and has operated adversely to its mining interests generally. At this time the Tomboy is about the only mine that is making any considerable shipments from the district of Telluride. The Argentine vein of this company is proving to be one of the richest lodes in Colorado. The Smuggler-Union and Liberty Bell groups have been idle for some time, but are now starting up under military guard. The Butterfly-Terrible mines, at Ophir, are again in operation and shipping.

Ouray.—The Camp Bird mines maintain a steady production, and developments continue to be highly satisfactory. Shortage of water, due to a peculiarly open winter, necessitated the recent closing of the mills, but the shut-down was only of a few days' duration.

Clear Creek.—This section has been making good progress during the year and is maintaining its usual steady production. In Upper Clear Creek the Terrible, Dives-Pelican and Seven-Thirty mines have been the regular shippers, and the close of 1903 notes the development of an important ore-body in the west end of the sixth level of the Centennial mine, which lies within the city limits of Georgetown. The Sunburst lease of the Red Oaks company is also making good shipments. The Doric-Griffiths consolidation promises to be a factor in the production of the near future. The famous Joe Reynolds group at Lawson is in good pay again, their deep 'tunnel' is completed, and from it a rich silver ore-streak is being mined.

In lower Clear Creek, the Gem Extension and Sun & Moon groups, have made the best showing for the year. In raising for connection with their main shaft through the Newhouse tunnel, developments in the Gem Extension have shown up well, and this company is making an addition to their mill, remodeling the older part of the mill, and getting ready for production on a much more extensive scale in the year 1904. The Sun & Moon group was set back by the strike, and will be remembered as the scene of violence and dastardly attack.

Though handling custom ore, the Newhouse tunnel has not been advanced in two years past. This great enterprise is likely to take on new life in the coming year, when arrangements are completed with the owners of the Saratoga mine, in Russell gulch, Gilpin county, to tap that vein in depth. The distance now lacking is a little more than 1,000 ft. The contract for this work is being negotiated, and the Saratoga mine has pulled its big Cornish pump in anticipation of a favorable agreement.

The Gum Tree mine is opening up rich lead ore carrying copper values. The Stanley Consolidated has adjusted its difficulties, and will, in the early part of the year, no doubt, be found in the front rank of the producing mines of the district.

Gilpin.—This part of the State has been going along much as usual, and can always be depended upon for its contribution. The Old Town Mining Company and the Running Lode (Gower Mines Syndicate) have taken the lead in the past year. The Running Lode production takes the form of a high-grade silver-lead ore, containing gold also. During the year it returned dividends amounting to more than 100 per cent on its capital stock. The output of the Old Town mines, while of lower grade than the Running Lode, probably tops it in the aggregate.

The Kansas Burroughs group, now being operated mainly through the leasing system, has been making a production ranging from 1,500 tons to 2,000 tons monthly in milling and smelting ores. Regular dividends have been earned by the Town Topics Company, working the East Notaway lode, in Russell gulch. This vein yields a high-grade gold-copper ore, and has in the past produced some rich telluride mineral.

The Specie Payment mine has done well in the past year, as also the Delmonico. The Saratoga mine is awaiting the extension of the Newhouse tunnel. This mine has been the main dependence of, and is under the same ownership as, the smelter at Golden. The smelter has been shut down for some months. Many of the mines of this district have been hindered by coal shortage at the close of the year.

Of the enterprises that point toward increasing activity and progress in Gilpin county, that of the Buell Consolidated is perhaps the most important. This company has just completed a modern and up-to-date mill, and is steadily augmenting its shipments, so that the close of 1904 is likely to see it attaining a more prominent place among the productive mines of the camp.

General.—Taking it all around, the close of the year saw the San Juan region of Colorado making the better progress and the best improvements. Leadville is doing close work, but there is nothing elastic about its present production, nor does it give promise of any change in the coming year. Nothing short of another Little Johnny is required to bring up the grade of the immense tonnage of low-grade fluxing ore produced by the Leadville district.

Aspen is contributing its share, but it must be considered as a district of declining activity.

Cripple Creek continues easily the premier mining district of the State, and from Cripple Creek we may look for something better than the story of 1903, with its chapters of strikes, strife, turmoil and coal shortage. These things, combined, have indeed "crippled" mining in the whole region, both in respect to the search for new ore-bodies, as well as in the development of established mines. It has had this effect temporarily, but temporarily only. The indomitable energy and ability that has created this great mining camp will not be denied.

MONTANA.

BY WILLIAM A. AKERS.

While the prosperity of Butte, the largest camp in the State, was interrupted by two serious shut-downs, mining throughout Montana generally was more active during 1903 than at any time in its past history. Several of the older districts have been revived, and a number of new camps also have been added to the list of producers.

On July 1 the Washoe smelter, at Anaconda, was closed so as to permit of finishing and connecting the new flue and stack, the flue being 2,300 ft. long, the upper 1,000 ft. being 120 ft. wide by 37 ft. deep, and the lower 300 ft. being 60 ft. wide by 37 ft. deep, and the stack having a diameter of 30 ft. and a height of 300 ft. The mines of the Anaconda, Parrot and Washoe companies, situated at Butte, were closed down while this was being accomplished, operations in them and at the smelter being resumed on September 15.

As the result of an action brought by John MacGinniss against the Boston & Montana company, Judge Clancy granted a temporary injunction on July 23, 1901, to prevent the Amalgamated company from receiving dividends upon or voting the shares of the Boston & Montana. A similar action having been brought by John MacGinniss and Daniel Lamm against the Parrot company, by agreement of counsel the decision in the case against the Boston & Montana was to apply to both.

On the morning of October 22, 1903, Judge Clancy rendered a decision making the temporary injunction permanent, and stating that while he would not at that time make any appointment, he would hold in abeyance the question of the appointment of a receiver for that company.

As a result of this decision the mines of the allied companies, comprising the Anaconda Copper Mining Company, Boston & Montana, Butte & Boston, Colorado Smelting & Mining, Parrot and Washoe were closed that evening, and the reduction plants at Anaconda, Great Falls and Butte ceased operations a few days later. On the afternoon of November 11, Governor Toole called a special session of the legislature to enact the necessary laws to secure justice for litigants in Montana, and all the closed mines resumed operations the evening of the same day.

Copper.—The four plants of the allied companies, namely the Washoe, at Anaconda, the Boston & Montana, at Great Falls, and the Butte & Boston and the Colorado, at Butte, treated 9,500 tons of ore per day, except during the suspension of operations mentioned in the preceding paragraph. Only three of the shafts of these companies were sunk deeper during the year: the Anaconda, 142 ft., the Parrot, 200 ft., and the Clear Grit, 300 ft. The Anaconda, Parrot and Washoe companies have completed a central pumping station on the 2,200-ft. level of the High Ore mine, from which the water is raised 1,900 ft. to the surface-tunnel, 300 ft. below the collar of the shaft, in three lifts. The equipment is in duplicate. The Boston & Montana company has installed a Nordberg pump on the 1,200-ft. level of the Leonard mine, which raises the water in one lift to the surface. Into this level is drained the water from its other mines, the Pennsylvania, Mountain View, East Colusa and West Colusa, making a flow of 500 gal. per minute, or about half the capacity of the pump. Mr. D. W. Brunton, consulting engineer for the allied companies, has designed and erected a large timber-framing plant at Rocker for mechanically framing round timbers for square-setting in the mines of these companies. It is kept running to full capacity, but in addition to the round timbers these companies have used 53,000,000 ft. of sawed timber during the year.

At the Butte Reduction Works, owned by W. A. Clark, a number of improvements have been made in the concentrator and a new furnace has been built. The plant has been running continuously to its full capacity, treating the ores of Mr. Clark's mines, the Original, East Stewart and West Stewart. At the West Stewart and at the Original, 36 by 72 in. double, first-motion, round-rope Nordberg hoisting engines have been installed and steel head-frames erected, the one at the Original having a height of 126 ft. from the collar of the shaft to the center of the sheave, being the highest in the camp. Skips are used.

The United Copper Company has increased the capacity of its concentrator at Basin from 900 tons to a maximum of 1,500 tons daily, and is treating an average of 1,300 tons daily, shipping the concentrates back to Butte to its smelter. The following are the operating mines of this company with the depths of shafts and approximate daily output: Minnie Healey, 1,150 ft., 500 to 800 tons; Corra-Rock Island, 1,400 ft., 400 tons; Rarus, 1,450 ft., 1,000 to 1,500 tons; Belmont, sinking from the 700 to the 800 ft. levels, and not producing. The copper values in the Corra have been leached out to the depth of from 800 to 1,000 ft. below the surface, but on the 1,200 ft. level a large body of high-grade glance has been developed. The Minnie Healey was closed by injunction July 1, at which time the Supreme Court ordered a re-trial and work was resumed.

The Pittsburg & Montana Mining Company has been pushing its development work underground and erecting its smelting plant with all possible expedition. One furnace is complete and the track from the north shaft to the smelter is finished. Everything is being done in the most substantial manner. This company recently purchased some mines at Elkhorn which are producers of heavy pyrite ores, and is now developing them.

The injunction which kept the Speculator mine closed during the last half of 1902 was removed, and it has resumed operations on a large scale.

In Beaverhead county the Indian Queen has been operating very successfully on its large bodies of glance and chalcopyrite, and is enlarging the smelter. The Copper Cliff has developed very satisfactorily and a concentrator for its ores is building.

In Jefferson county, Bird, McCabe and King have acquired, by location and purchase, 175 claims and 320 acres of ranch land in the Corbin district, and are sinking three 2-compartment shafts upon them. Chalcopyrite and bornite are found at the surface.

Gold.—The extension of the Montana railroad from Harlowton to Lewistown has stimulated the operation of the large gold deposits of Fergus county. The Kendall property and the Barnes-King group, in the North Moccasin mountains, are operating their large cyanide plants, the former treating 350 tons and the latter 240 tons daily. Development in both these properties has been very encouraging.

The Gold Reef Mining Company, at Gilt Edge, is operating its large mill with very satisfactory results. Several smaller plants are being operated with success in this district. On the Big Six group, in Whiskey gulch, near Gilt Edge, 70 men are employed blocking out ore, and a large cyanide plant is to be constructed.

In the Marysville district, the Drumlummon mine, owned by the Montana Mining Company, Ltd., is operating its 40-stamp mill, and during the summer successfully cyanided a large tonnage of slimes remaining from accumulated tailings. During the last six years it has treated by cyanide about half a million tons of tailings. The group comprises a large number of claims, and development work is being energetically prosecuted above the 400-ft. level, or 'deep tunnel' level, north and south of the old workings. The Bald Butte mine, in the same district, has not been operating its mill during the latter half of the year, development work only being done.

Near Helena the Big Indian Gold Mining Company has been operating its 60-stamp mill with very satisfactory results.

A. C. Burrage, who was operating the Clipper and Boss Tweed mines, at Pony, in Madison county, has discontinued work and has leased the mines to W. W. Morris. The Kearsarge, eight miles from Virginia City, has absorbed the old Kennett property, and is removing the 60-stamp mill from the Kennett to the Kearsarge. It has been shipping, operating an old five-stamp mill and blocking out its reserves. The U. S. Grant, near the Kearsarge, is erecting a mill. The Revenue-Monitor, at Norris, is installing a cyanide plant. The Watseka Gold Mining Company, at Rochester, has opened its mine to the 600-ft. level and has over 10,000 ft. of drifts, of which 3,000 ft. have been run during the year. It is the wettest mine in the State, having a normal flow of from 650 to 700 gal. of water per minute, all of which has to be pumped to the surface. A force of 160 men is employed. The old mill, having a capacity of 40 tons daily, and employing cyanide, amalgamation and concentration, was run until August. The new mill, daily capacity 150 tons, was completed July 1, and has put through 13,000 tons.

In Deer Lodge county the old Cable mine, which has produced more phenomenally rich gold ore than any property in the Northwest, but which was regarded as worked out, has been operated very successfully during the year by a Butte syndicate, of which Mr. F. W. Bacorn is at the head. The 20-stamp mill has been run a good portion of the time, and a part of the resultant profit applied to energetic and systematic development. In the Gold Coin, two miles from Cable, a rich strike has just been made and some truly magnificent specimens secured. The extent of the strike is not yet determined, but the specimens exhibited contain several thousand dollars in visible gold. The old Southern Cross, near Cable, which has been idle for a number of years, is under lease and bond to Mr. Lucien Eaves, who has been shipping considerable tonnage to Anaconda by wagon, a distance of 17 miles, and who is now erecting a cyanide plant. Large bodies of ore are developed. A 10-stamp mill is going up on the Amazon property.

The Kimberly-Montana Gold Mining Company, in Bear gulch, Park county, is operating successfully, and has just completed a 40-stamp mill. The Ajax mine, at the head of Big Hole Basin, after operating its five-stamp mill successfully for a year, is installing a tramway and ten additional stamps. The Jay Gould, in Lewis and Clarke county, one of the productive mines of Montana's early days, is being equipped with a cyanide plant, after years of idleness. In Flathead county a large amount of encouraging development has been done on the free-gold veins of the West Fisher district, while in the Libby district several properties are showing up handsomely. The Snow Shoe Mining Company is doing extensive work on a large concentrating proposition, having values in gold, silver and lead.

Jefferson county has been the scene of much mining activity, and the Penyan, Blue Bird, Ada, East Pacific, Bertha, Eva May and Liverpool are among the list of producers. On the Bullion properties, ten miles from Basin, M. L. Hewitt is erecting a smelter.

Gold Dredging.—Five dredges have been in successful operation during the season, three near Laurin, working on the old Alder gulch placers, one in French gulch, 20 miles west of Anaconda, and one operating four miles below Bannock. At one time there were five boats on Grasshopper creek, in the Bannock district, but four of them have worked out their ground. They secured nearly a million of dollars from this abandoned placer.

Silver.—The Granite-Bi-Metallic property has been operated on a large scale during the year, until the latter part of July by Mr. Paul A. Fusz as manager, from then until December 1 by him as receiver, and during December by the same gentleman as manager once more. The old Hope Mining Company, which built the first silver mill in Montana, has changed its name to the Good Hope Mining Company, and is being operated by the Granite-Bi-Metallic Company. In Walkerville a considerable tonnage of silver ores is being extracted by lessees and some rich strikes have been made. C. W. Ellingwood, who has been leasing on the Goldsmith for the past six years, has shipped $75,000 during the last three months. At Saltese much activity has been displayed during the past year, and developments have been very gratifying. A large body of high-grade ore has been developed on the 400-ft. level of the Tarbox.

Coal.—The Horr and Red Lodge mines are being extensively worked, as are also the mines of the Anaconda company at Belt. The Washoe company's mines at Storrs are the most largely developed of any in the State, and have 100 coke ovens in operation and 100 more building.

NEVADA.

BY J. E. SPURR.

Since the discovery of Tonopah, in the summer of 1900, the desert State of Nevada has entered upon a period of renewed interest and activity in mining matters. The opening up and development of the rich silver and gold ores of the Comstock and Eureka, together with other famous camps, a few decades ago, was followed by the gutting of these mines, the decline in the price of silver, and the inevitable reaction which is the sequel to a period of reckless investment. Nevada declined, and its busy mining towns were deserted, sometimes almost to the last inhabitant, till to-day two representatives in the United States Senate stand for a population of about forty thousand.

Nevertheless, the State possesses in an eminent degree the first qualification for a successful mining industry: it has the ore. The geological conditions are exceptionally favorable. During the Tertiary period, this region was the scene of repeated and extensive volcanic eruptions, which were accompanied by the formation of mineral veins. Most of the rich deposits thus far discovered—such as the Comstock, Eureka, and Tonopah—were formed at this period. Moreover, the naked unvegetated reaches of the mountain ranges which separate the flat desert valleys, and the frequent deep cañons, offer to the prospector facility for finding whatever of valuable material may be contained therein.

On the other hand, there are certain adverse conditions which, until recently, have kept away the gold-seeker and the capitalist. These are the lack of water and fuel, and the consequent difficulty both in prospecting and in profitably mining ores when found. Added to this has been the damaged reputation of the region, as being a silver State, which could only expect to improve at that distant day when silver should be rehabilitated as a money metal.

Tonopah is a strong argument against these prejudices. Its discovery, like that of many another mining camp, was almost a matter of chance. The ore was a barren-looking quartz, and passed from hand to hand for some time, before it was finally assayed. But its richness, and the demonstration that it could stand high freighting and smelter charges and still pay a profit, soon commended the camp to investigators. The outcropping veins at Tonopah, which cover a comparatively small area, became the property of the Tonopah Mining Company, and concentrated most of the attention of the public till this present year, so that Tonopah was wont to be wrongly called a one-mine camp. This company shipped to smelters ore to the value of a third of a million dollars in 1901, and of a million and three-quarters in 1902. In 1903 shipments have been actively made, but the general policy of the company has been to develop systematically and to plan for the future reduction of the already blocked-out ore reserves, both the shipping ore and the lower grade, at a better profit than at present. When it is understood that in Tonopah ore must run in the neighborhood of $100 to the ton or more, in order to be good shipping ore, the importance of these large bodies of so-called low-grade material is evident.

The year was an important one in Tonopah, on account of the development of ores beneath later volcanic cappings, outside of the area of the outcropping veins. The Montana Tonopah, not far from the Tonopah Mining Company's main shaft, encountered, at a depth of several hundred feet, strong veins, containing bonanzas rivalling those of the Mizpah ledge of the older company. The Montana Tonopah is understood to have shipped about $100,000 worth of ore in the calendar year of 1903, and a dividend of 5 per cent on the stock was declared in December—the first in the camp. The North Star has cut similar, or possibly the same, veins near by. The Desert Queen shaft, on the Belmont property, also encountered rich bonanzas at an advanced depth. The Midway and the Tonopah Extension have encountered veins, carrying relatively good values, several hundred feet below the surface. In the latter mine some very rich ore has been taken out. Everything considered, therefore, the development of the camp is going on very satisfactorily. It is true that many of the explorations, other than those mentioned, have met with no success, and some of them have stopped from lack of funds. With as little as the Tonopah people have had to guide them, in the way of exploration, such an outcome must be inevitably the case. Increased attention to the geology of the district will partly remedy this.

Tonopah is fortunate in having apparently solved the water problem. Until a few months ago, the water for the town was a scanty supply from shallow wells several miles away; but experimental boring in a shallow flat has developed an abundant supply. Moreover, some of the shafts in camp have encountered a copious flow of water, necessitating one of them, the Halifax, to shut down pending the arrival of a pump. The water from this mine will be used for milling operations.

The question of transportation has been an important one, and several schemes have been on foot. A railroad was projected from Tonopah to Daggett, in the Mohave desert, there to connect with the Santa Fe Railroad, but the plan is one that requires considerable outlay. A spur from Tonopah to some point on Senator Clark's proposed San Pedro, Los Angeles and Salt Lake Railway, connecting with the main road perhaps at Las Vegas, has been under consideration, and is perhaps not unlikely, although this could not be carried through for some time. The cheapest expedient evidently is to connect Tonopah with the Carson & Colorado Railroad, which is a branch of the Southern Pacific, and has its nearest point some 60 miles distant. Plans were made early in the year for such a connection, but they were not actively followed out, and now the Tonopah Mining Company has taken up the matter and is actively pushing it as its own undertaking. The railroad to connect Tonopah with Rhodes, near Lodeville, on the C. & C. railroad, is now under course of construction, and is expected to be running this summer.

Prospectors from Tonopah have located many new and old claims for several miles around, and while many of these camps are consumers rather than producers, some likely-looking deposits have been developed. Gold Mountain, about four miles south from Tonopah, has some good gold ores. Lone Mountain, 15 or 20 miles to the west, has a number of companies, often fraudulently classified as being in the Tonopah district. Some of these are stock-jobbing rather than mining operations; but others have produced ore. The Nevada Alpine, bought last year for a reported sum of $7,000, has in 11 months paid $70,000 in dividends to the owners. Many other camps, for the most part of growing importance, can be traced directly to the stimulus of the mother camp.

About 23 miles southeast of Tonopah, and 6 miles east of the old camp of Montezuma, a new discovery was made in the summer of 1903, and named Grandpa. The name has now been changed to Goldfields, and the camp is attracting much attention, large quantities of high-grade gold-ore having been developed. The Combination and the January are among the principal mines. The ore contains practically no silver, and occurs in silicified reefs in a rhyolitic rock. A town has sprung up here, and active development is in progress. Outside of Tonopah and Goldfields it is doubtful if there has been any very marked increase in the actual output of the State, though the mining business has held its own, and activity in prospecting and developing has greatly increased. Besides Nye county, in which Tonopah is situated, the two chief mining counties are Storey and Lincoln. In the former is the Comstock lode, steadily continuing its existence, though the rich ores which made it famous have been abstracted and only low-grade ores (meaning here $15 to $20 a ton) remain. During the past few years a combined attempt of the Comstock companies has been made toward creating better economic conditions, so as to make the working of the cheaper ores profitable. Electric power has been brought from the Truckee river, in California, 37 miles distant. In 1899 the work of unwatering the lower levels of the mines began with a hydraulic elevator. The work has been in progress since that time, but it is not yet completed. There are now eight producing mines on the lode, the Consolidated California and Virginia, Caledonia, Andes, New York Consolidated, Silver Hill, Yellow Jacket, and Justice. Over half the product of these mines comes from the Consolidated California and Virginia. For the year ending September 30, 1903, this company extracted 4,607 tons of ore, and the total yield of bullion for the ores sold or worked was $128,571. In the neighborhood of 500 men were employed in the Comstock mines, not far below the number employed at Tonopah.

Lincoln county possesses the De La Mar mines, another proof that, with energy and capital, desert mines may be made to pay. This district was not so fortunate in regard to its water as Tonopah has been, for none could be found near the town; so it has been pumped from the other side of a mountain range. De La Mar lies on the west side of the range, and the Meadow Valley wash on the east side. From a well in the wash the water is pumped, with a total lift of 1,500 ft., to the summit, and then flows by gravity to the camp. De La Mar has followed the example of the Comstock in installing electric power. This work was completed in the early summer of 1903, the plant being 1,200 h. p., and able to furnish power to treat 700 tons of ore per day. The ore contains about equal values of gold and silver. This mine continues to hold its rank as the chief gold producer of the State.

In the extreme southern part of Lincoln county and of the State, near the Colorado river, the district of Searchlight has been active in producing, and a good deal of prospecting is going on near there. The Quartette mine has been working on its 600-ft. level. The ore is a gold ore and is treated in a 30-stamp mill, with auxiliary cyanide plant. This mine, as well as the rest of the district, lay idle for several months in the summer of 1903 as a consequence of the strike epidemic, which also threatened to invade Tonopah, but was happily averted. Nevertheless, a production of several hundred thousand dollars is credited to it for 1903.

Besides the principal camps, mentioned above, a considerable number of smaller mines in all parts of the State, which have been steady producers for years in a small way, continue their operations, and many new enterprises, both in virgin ground and in long-abandoned camps, have been begun, some of which are paying profits.

The building of the San Pedro, Los Angeles and Salt Lake Railroad will give a great impetus to the mining districts in the eastern and southern part of the State, which will be furthered if some connection is made between this road and Tonopah. The question of fuel may be solved to a large extent by the use of electric power, and the finding of water, recently, in shafts at Tonopah and Searchlight, holds out the hope that it may be secured when sought for, in many other localities.

SOUTH DAKOTA.

BY SAMUEL S. ARENTZ.

The Black Hills mining industry has been active during the year. There were more companies formed in 1902 than in 1903, but the past season has seen an increased amount of development work in new territory.

The output of gold bullion in the Black Hills for the year ending November 1, 1903, reached a total of $7,159,400, according to Mr. Thomas Gregory, the State mine inspector. Of this amount, approximately $25,000 was recovered from placers in Beach gulch and elsewhere.

Lead City is the principal mining center of the Black Hills. With the exception of the Deadwood-Standard, Spearfish, Clover Leaf and Holy Terror companies, all the large producing mines are within a radius of not more than 10 miles of Lead. The Homestake Mining Company, which produces the bulk of the Black Hills bullion, is situated here. The company treats over 3,000 tons of ore per day. It produced $4,500,000 in 1903. Its output has been increased by the addition of 100 stamps to the Amicus mill. By the addition of six new vats to cyanide plant No. 1 the Homestake company will be in a position to treat a total of 3,000 tons of tailings per twenty-four hours. The company's mine development is keeping up with surface improvement.

Adjoining the Homestake on the west, the Hidden Fortune Company has carried out extensive exploratory work. Its new plant, below Deadwood, has been running intermittently the past year. Amalgamating plates were installed as an addition to cyaniding, and under present management the mill is running steadily.

The Pennsylvania company has been developing its property in Rutabaga gulch, and adjoining it the Gladiator company has done some drifting, and has sunk a shaft in Deadwood gulch. This company is also developing the Gold Fish group, in the southern hills.

The Globe Mining company's shaft, in White Tail gulch, above Lead, has reached a depth of 750 feet. The Oro Hondo company, which has a large acreage, is sinking a shaft on the Homestake extension, below Kirk. The shaft is now 950 ft. deep.

At Maitland, in Black Tail gulch, the Columbus company has been sinking its shaft rapidly. Cross-cuts were driven from the 200 and 500-ft. levels into the Algonkian schists and other developments carried on systematically. The company's 75-ton wet-crushing cyanide plant, at Gayville, treating Potsdam silicious ores, ran steadily until recently, but shut down owing to a lack of transportation facilities. The Penobscot, situated at Garden City, has been in continuous operation, treating from 100 to 150 tons per 24 hours.

Previous to closing down in the early part of 1903, the Imperial dry-crushing cyanide mill, at Deadwood, treated 17,000 tons of ore from Black Tail and the Bald Mountain district, and $90,000 in bullion was produced. At present a force of men are at work renovating the mill, and at an early date it will be put in operation. Ore from Black Tail, Crown Hill and Bald Mountain will be treated by cyanide in this plant.

The Rossiter cyanide plant, also at Deadwood, was operated for the greater part of 1903 by Dorr & Lundberg, who treated ore from their Buxton and Big Bonanza mines, in Fan Tail gulch, near Terry, and also custom ore. They ceased operations at Deadwood when work began on their 100-ton cyanide plant at the mines. During the year they produced $75,000 in bullion. Since early in February the Lundberg, Dorr & Wilson cyanide plant at Terry has been treating 50 to 75 tons of ore per 24 hours. At this plant the ore is pulverized by a Chilean mill, the Moore slimes process is used, and the entire mill run by motors, the electricity for which is transmitted a distance of six miles.

The Dakota cyanide plant is in full operation, treating 100 tons of silicious ore per day from Bald Mountain. The Golden Reward cyanide plant has been in continuous operation, treating 200 tons of quartzite ore per 24 hours. The Golden Reward smelter, of 350 tons daily capacity, situated near its mill, in lower Deadwood, ceased operations in the middle of the year on account of labor troubles and the high price of coke. The combined bullion output for the year 1903 was $1,008,310.

At Galena and vicinity the Lexington Hill mill, in Spruce gulch, is in operation, and the Golden Crest 10-stamp cyanide plant in Strawberry gulch is treating 48 tons per day. Wasp No. 2, in the Yellow creek district, has been working steadily on the quartzite, and produced $80,000 during 1903. The Alder creek cyanide mill, adjoining the Wasp No. 2, has lain idle for the greater part of the season. Like its neighbor, most of the ore is mined by open cuts in the flat quartzite deposits. In this vicinity several new companies have done active work, and a fair amount of development has been done by individual owners.

The Clover Leaf Mining Company, between the Germania and Bare Butte districts, on Elk creek, is dropping 40 stamps on free-milling quartz. Its work during the past year has given an incentive to exploration in that locality. The output for the year amounted to $100,000. There has been much energy shown during the past season in the Bald Mountain district, near Portland and Terry. All the ore treated from this district is known as the Potsdam silicious ore from the flat, blanket formation in the lower and middle Cambrian. The shafts seldom reach a depth greater than 250 or 300 ft., and much of the ore is mined from tunnels and open cuts.

In the early part of the year the Horseshoe Mining Company shipped from 400 to 600 tons of ore per month from the Ben Hur mine to the National

Smelting Company's plant, at Rapid City. Its new 600-ton cyanide plant was put into operation early in September, since which time it has been treating 300 tons daily. Most of this ore is mined in open cuts on the Passaic, Sunnyside, Black Moon and McDonald, and more permanent developments are progressing on older properties.

The Reliance Milling & Mining Company, formerly the Aksarben and University mining companies, situated on Annie creek, has done some grading on a mill-site, and contemplates the erection of a 300-ton plant in the near future.

At Ragged Top, the Spearfish mill, of 250 tons daily capacity, and the Deadwood-Standard, of 100 tons, have been working steadily on ores coming from the limestone. During the year 1903 the Spearfish company treated a total of 63,484 tons of ore, with a bullion return of $269,661. The Deadwood-Standard produced gold to the amount of $87,500. The Victoria Mining Company is also developing mines in this locality.

There has been increased development work in the southern hills in the vicinity of Rockford, Silver City, Keystone and Pactola. The Ohio-Deadwood, at Rockford, has opened up some free-milling low-grade ore. The Golden West 10-ton plant was operated for several months, and a Huntington mill was used on the Cochran property. Several other companies have done more or less work in this district, and some development has been accomplished at Mystic, as well as on the lead-antimony properties about Silver City. A plant was erected at Pactola, during the summer of 1903, to treat the creek sands by the cyanide process. During the past spring two more of a similar character were completed in the same vicinity.

Some work was done near Keystone in the extraction of mica and spodumene. The Grantz Mining Company sunk a shaft 280 ft. and did much surface work. The North Star treated small amounts of ore in its 10-stamp mill, and other properties in the vicinity underwent a small amount of exploration.

The Gilt Edge Maid Company, situated four miles east of Deadwood, have under construction a 75-ton cyanide plant. The Ivanhoe Gold Mining Company have installed a compressor and hoist. The Nigger Hill district has seen renewed activity. The Tinton Company, in Bear gulch, which is exploiting tin deposits, has had men busy all the season. At present the company is treating 60 tons of tin ore in its concentrating plant.

The Golden Empire Company is sinking two shafts on auriferous bodies, as well as developing tin prospects. It is reported that a good deal of stream tin has been washed from Bear creek during the past season.

UTAH.

BY JAMES W. NEILL.

The leading mining districts of Utah exhibited healthy progress during 1903, as the following account will indicate:

Park City.—This is primarily a silver-lead camp, and its output goes to the smelting works of the American Smelting & Refining Company. This district prospered during the year 1903, partly owing to the enhanced price of silver and lead and partly owing to the large amount of outside money spent in development.

The Silver-King and the Daly-West mines are the leaders; each has shipped about the same amount of ore (75,000 tons), and each paid about $1,300,000 in dividends; each, also, has maintained its reserve of both money in treasury and ore in sight. Improvements in the surface plants of these two mines are not of material moment; each keeps pace with the times and with the demands of its output. The Daly-Judge, which started the year with a mill of moderate size, has increased the capacity during the year and maintained regular shipments of concentrates. The destruction of the separating plant which handled the zinky middlings curtailed this output, and terminated efforts to make Park City a zinc-producing camp. The development of the Bonanza flat portion of the Daly-Judge ground has progressed favorably and some rich ores have been encountered. It takes time to make a mine, but this ground should soon make important shipments. The Ontario is now building a concentrating mill, in which to handle the large tonnages of low-grade base ores long held in reserve. The shipments have not been heavy from this property, but quite a little money is said to have been earned through excavations beneath the old mill, where it has been found that the quicksilver from the amalgamation process had penetrated the earth to a surprising depth. The Comstock has erected a concentrating mill, as has the Keith-Kearns mine, and both these properties will join the ranks of producers in 1904.

Of the many companies floated in 1903 there are a number which, from present information, will be producers in the near future, such as the Naildriver, St. Louis Vassar, Scottish Chief, Keystone, and New York.

Bingham.—This district had a good year. The Highland Boy mine of the Utah Consolidated kept up its steady work, added to its reserves a new intermediate ore-body of high grade, commenced the construction of important enlargements to the smelter, and has been the largest producer of copper in the State; with an output of about 13,250,000 lb. during 1904, the new part of the plant will enable this property to produce, from an additional 250 tons of ore, about 7,500,000 lb. more, so that this mine in 1904 should yield close to 20,000,000 lb. of copper. The mine, it is said, has never looked so well, and the entire plant is a model of business-like management which appeals to every visitor. The Bingham Consolidated has succeeded in unwatering its Dalton and Lark mines, and these are responding to development in a very satisfactory way; the Commercial is a regular shipper, and the smelting plant in the valley has been operating with its usual clock-work precision. This company has produced during the year between 8,000,000 and 9,000,000 lb. of copper bullion, and, as this plant has a blast-furnace process and handles a great deal of silicious ore, the bullion product is of much greater value than that of the Highland Boy. These silicious ores have been purchased from the mines at Tintic and other camps, at prices leaving a good profit to the shippers; the Bingham company, however, has recently purchased a control of the Eagle & Blue Bell mine in Tintic, and with this in their own hands the company will be in a more independent position. Everything looks prosperous for the Bingham companies, and their output will be materially greater in 1904 than in 1903. The United States Mining Company has been a regular producer during the year, the mines have supplied the wants of the smelter, and this has been operated steadily and successfully throughout. For a period the shipments from the Centennial Eureka of this company were shut off by a fire in the neighboring mines, but this did not interfere with the production. Developments in the United States mines have kept pace with production, and the reserves are said to be greater now than at any period in the history of the company. The directors are considering the erection of a lead-smelting plant, in addition to the copper furnaces. This company produced about 8,000,000 lb. of bullion, and this is the highest in grade of any sent from the State. The Boston Consolidated Company has begun an era of production by shipping to the United States and Bingham smelters a small tonnage of ore; this has been of such good grade as to remind one of the first shipments from the Highland Boy. The copper Belt Railway is now completed to the ore-bins of the Boston Consolidated, so that regular and large shipments will now be made to the valley plants; meanwhile the best process and appliances are being studied with a view to erecting a smelting plant. The ore-bodies in the Boston Consolidated are of such magnitude that these shipments will practically come from development; indeed, those best informed compare the Boston with the Highland Boy, and congratulate the camp on having two such mines. Close to both these mines in Carr Fork is the Yampa of the Tintic Mining & Development Company. Here the year has been given to opening up the ore-bodies, shipments from development work only being made; these have shown the values to be like its neighbors, the Highland Boy and Boston Consolidated, and of such grade as to pay well even when shipped to outside smelters. This company has now completed, in the main cañon a short distance below the town of Bingham, a smelting plant of 250 tons daily capacity, equipped, however, with power, dust-flues, stack, bins, etc., for double that tonnage. This plant will be started up before the new year, and thus another considerable tonnage will be forthcoming. The shipments from the Yampa smelter will be in the form of matte and will go to one of the valley plants to be reduced to copper, but the total metal output of this mine should be not less than between 6,000,000 or 7,000,000 lb. for the year 1904. An enormous deposit of concentrating porphyry has been acquired by the Utah Copper Company, and they have a mill of 500 tons daily capacity now well on the way to completion. This mill is situated about 1½ miles below the town, at a point where abundant water can be had from bed-rock; to this point the ore will be hauled by railroad. This mill is considered by the builders only in the light of a demonstration, and, if the returns are as expected, they will proceed to erect a plant to handle 2,000 tons daily; they will then doubtless also go into the smelting part of the business, but at first they will be shippers of concentrates carrying about 25 per cent copper.

This 500-ton mill when in operation should add to the metal output at the rate of about 5,000,000 lb. per annum. The outcome of this venture is of the greatest importance to the copper production of the district and of the State, as the quantity of the material available is very great.

Close to the Utah Copper Company's ground is the Columbia mine, which has lately been acquired by the Ohio Copper Company; this company is now re-equipping one of the old concentrating mills and will soon start out with a production of over 100 tons per day, the ore averaging about 5 per cent. Besides this, they ship a considerable quantity of higher grade ore to the smelters. The property is capable of producing an enormous tonnage of low-grade material similar to the Utah Copper Company, and when the latter demonstrates that there is a profit in this material we can look for the erection of a much larger plant for the Ohio Copper Company. Prospecting and development is going on all around the leading mines, and there are many good indications of more producers developing during 1904. These properties in Bingham, as described, promise to yield from their own and, in some part, from Tintic ores also, close to 60,000,000 lb. of copper per annum, an amount which will obtain the attention of the market.

Tintic.—This large district, embracing the camps of Eureka, Mammoth, Robinson, Silver City and Knightsville, has come to the front again, doubling its shipments over last year. The increase is due largely to the big output from the Centennial Eureka of the United States Mining Company, and from the dumps of the Grand Central mines, as also from the iron mine of the Dragon and Black Jack. About 175,000 tons, in all, have gone to the valley smelters. The reduction works in the camp are all closed down, but the May Day and the Uncle Sam have both built small concentrating plants to handle low-grade ores, and it is rumored that a large plant for the re-working of the Mammoth tailings will be erected during the year. The Centennial Eureka is the largest shipper in point of tons and in value of product, and the mine is said to be improving with depth. The Gemini has been a large shipper of high-grade silver-lead ores to the American Smelting & Refining Company, and this mine has reached the lowest level in the camp and has there found the ores changed to sulphides, but of better grade, an excellent promise for the future of the camp. The revival of the eastern end of the district at the Yankee, the Godiva, Uncle Sam, and Tetro, is of importance, and in most of these properties the ore-shoots which formerly appeared only to be superficial now seem to continue downward. The Tetro became a new shipper during 1903, and promises well for 1904. The Bullion Beck, Mammoth, Ajax, Sioux mines, and the Swanseas at Silver City, are dormant; on the other hand, the Grand Central has found ore-bodies in new ground and is looking particularly well. Fluxing iron for the American Smelting & Refining Company has gone out in large volume from the Dragon and the Black Jack. This carries an excess of about 53 per cent iron, but contains no precious metals.

Mercur.—It may be said that the Mercur is about the only camp where we must note retrogression; the old reliable Mercur Consolidated is still working, has installed a slime plant and is still taking out ore in large quantity, but the grade does not keep up, and the costs increase with depth, so that the outlook is not so good as it was last year. Other mines in this district are dormant, and the "Johannesburg of Utah" is very quiet.

On Gold Mountain, in Piute county, the Annie Laurie has continued to maintain a regular output, in spite of a shut-down during the summer on account of labor troubles; the lower tunnel is now near the vein, and this year should see the bonanza increase its output. The Sevier Consolidated has added a mill this last summer, and the development of the mine has been most gratifying, so that the district can point now to two producers and to a number of most promising prospects.

Frisco and Milford.—Near Frisco the Cactus mine is being pushed rapidly forward as an immense copper proposition; its orebodies are being developed by means of a long adit, water has been piped many miles for milling purposes, and plans for a town, an immense mill and a branch railroad are well under way; all these will doubtless mature during 1904, and thus another important source of copper will be added to Utah's list. The output of this mine will go for a period to the smelters now erected, but the well-informed expect that Mr. Newhouse will build a smelter for the Boston Consolidated and Cactus together, and thus take care of both outputs. The Majestic company finished its smelting plant and has made a very successful initial run, closing down recently to continue development on its mines. The matte shipped has been of excellent grade, and thus promise of further copper product is given. The many prospects round Milford should help this smelting plant with an ore supply, and possibly enable it to maintain a steady production. At the old Horn Silver I hear that a plant to handle the tails by some new method is to be installed; this would help out this old producer, the ores of which carry too much zinc for the usual methods.

Alta.—The famous old camp of Alta has been the scene of much development work during the year and promises to show up with several good producers during the coming summer. The great plant of the American Smelting & Refining Company at Murray has run to full capacity and has smelted a total of over 40,000 tons of ore per month. There is a well authenticated rumor that this company intends to erect a copper smelting plant of large capacity in the near future, and at some point near at hand; if this is done, the Salt Lake Valley will be a smelting center unexcelled; even now the valley plants handle up to 100,000 tons of ore per month.

The strikes in the coal-fields and coke-ovens have interfered with the output of some of the smelting plants; they have all resorted to Connellsville coke at high prices, but this trouble promises to be of short duration, and at the present time it is the only cloud on the industrial horizon of Utah.

MINING IN WYOMING.

BY HENRY C. BEELER.

This year has been marked by great general activity in all the camps of this State, and more actual development has been accomplished than in any previous year in the history of Wyoming mining.

In the Grand Encampment copper district in Carbon and Albany counties, in southern Wyoming, work has been carried on with increased facilities, some fifty steam plants being in place at the most prominent properties, and the season's work has accomplished a great deal in the permanent development of the camps.

The portion of the district which shows the greatest advance for the year is that lying along the Wyoming-Colorado line, near Pearl, Colo., where the Coldwater, Mt. Zirkel and a number of other mines are in condition to ship as soon as facilities are presented.

The success of the Encampment reduction works has given confidence to others, and a similar works for the Pearl district is projected by some of the principal owners of that locality. Work is to be commenced in the spring, and in the meantime underground development goes on. The ores of the Pearl district are similar to those of Encampment, being mostly chalcopyrite in a schistose, quartz gangue.

The North American Copper Company, owning the Ferris-Haggarty mine at Dillon, the Encampment Aërial Tramway, the Encampment Smelter, and allied works, has been doing development work only in the Ferris-Haggarty mine, and now has 280,000 tons of 6 to 8 per cent copper ore, with small gold and silver values, blocked out and ready for stoping. Further development is being carried on in a winze below the main operating tunnel level, and latest advice shows no decline in size of vein or grade of ore. No stoping is now being done in this mine, all shipments having been cut off in December last, and only work necessary to put the mine in shape to produce its full capacity next summer is being carried on.

During 1903 the surface plant at the Ferris-Haggarty was overhauled and moved to the main tunnel mouth, where compressors and power and light plant have been installed, and all necessary buildings substantially constructed. A system of compressed air haulage was put in to convey the ore from the chutes to tramway terminal, and the ore-handling facilities were otherwise improved. The tramway from the Ferris-Haggarty mine to the Encampment smelter, a distance of sixteen miles, has been in daily commission, and has been generally satisfactory, although some changes are in progress, such as placing new towers, tension stations, etc., at points developed by experience in snow, winds and other local conditions.

At the Encampment smelter the plant has been enlarged to a 500-ton capacity basis, and a concentrating, roasting and briquetting plant added, and converters installed, to produce blister copper instead of shipping a 50 per cent matte as heretofore. Some changes were necessary in the arrangement of this plant, but the runs made have been satisfactory to the management. These runs have been made at different times during the fall as convenience dictated, and the plant has been thoroughly tested and improved; the concentrator was started in June and the smelter blown in September. The highest day's run was 24,556 lb. of copper. All machinery connected with the smelter and converter is electrically operated, but the concentrator is driven by direct rope drive from the water-power plant.

At the Doane-Rambler mine, on Battle creek, a new drainage and development tunnel has been run in, and a cross-cut driven under the main shaft, which will be equipped with hoist, etc., and sinking resumed. Some stringers of very high grade copper glance and black oxides were cut during the above work and sacked for shipment. This company has also put in extensive surface works, compressors and power plant, and is now in shape to proceed on a practical development basis; seventy men were put to work the first of the year, and development is being pushed as fast as possible. This property is owned by the Battle Lake Tunnel Site & Mining Company, and is the oldest producing mine in the district, having a record of one-half million pounds of copper produced, the first shipment having been made in 1895, and the balance at varying intervals. This mine holds the record for rich ore, some of the cars shipped averaging 51.3 per cent copper.

On the Verde property, south of Battle, work has been steady all season and results highly satisfactory. This is the property referred to in the United States Geological Survey report upon the Encampment district, by Mr. Arthur Spencer of the Survey, as showing characteristic ore conditions distinct from the secondary deposits of the Ferris-Haggarty and Rambler mines. The active development of the Verde is being noted with interest by mining men of that locality, and the successful exploitation of a property of this class will mean much to the district generally, as no producer has yet been developed on the primary deposits noted here and at several points less well known.

The New Rambler, east of Encampment, shipped some high-grade ore and considerable matte from their small matte smelter during the first part of the year, but have been shut down recently, pending the adjustment of the company's affairs. No further developments have been made in the platinum values found in the covelite ores of this mine, but similar ores have been reported from properties near the Rambler. The production for this property is given at 249,202 lb. copper for 1903.

The American Mining Company, near the Rambler, has installed a plant suitable for deep mining, and is steadily sinking a three-compartment shaft.

Some small work being carried on by the Ak-Sar-Ben Company on a huge oxidized iron ledge on Iron creek, west of the New Rambler, has recently shown some fine copper, and the size of the ledge indicates an extensive body similar in class and occurrence to the Doane-Rambler and other secondary deposits.

At Silver Crown, Slate Creek, and other camps in the Laramie hills, work has been steady all year, and results are tangible. North of Laramie Peak five new plants are in operation, where last year nothing was done. In the latter vicinity the Esterbrook has been developed on a ledge of silicious lead carbonate, but this is now giving place to copper pyrites. Other properties in the same locality show an entirely different surface condition, but a similar copper sulphide ore at depth. In the old Warbonnet district, further west, the Oriole mine is making a fine showing in copper and gold.

In the northern part of the State permanent works are being constructed at Kirwin, on Wood river, and at Sunlight, north of Cody; at Copper Mountain, near Thermopolis; on the South fork of the Stinking Water river, the results attained are very satisfactory. These works are principally interesting from their varied showings, and the fact that they have been developed in localities long despised and rejected of mining men, but they will certainly be noted in the production reports of the State in the near future, and are worthy of the serious attention of the mining world.

Accurate statistics of Wyoming productions are rare, but they have been brought to date with great care. The State's production of copper for 1903 was 947,106 lb., and the total from 1883, the earliest known production, to 1903, 10,986,092 lb., value $1,726,729.

The South Pass gold district, in Fremont county, has been more active than for many years, the Dexter Mining and Development Company's work at the Tabor Grand, Rose and Dexter cross-cut development tunnel at Atlantic being permanent work; the latter work marks an important step in the progress of new mining in this locality, as work heretofore has been mostly of a superficial character on isolated lenses of high-grade ore, the low grades being ignored in the old days.

The Carissa at South Pass has been running steadily on development work without stoping; only the better grades are milled on the property, the low grades being blocked out and left for future operations.

At Lewiston the Strawberry, Burr and other properties have changed hands and are working steadily.

These properties have been thoroughly examined, and numerous treatment tests on carload lots were made, so that successful treatment of these ores is now expected. Heretofore attempts to mill the South Pass district ores have not been very successful, the stamp mill having been the most popular method, and savings small. Cyanide practice adapted to the need of each ore has so far given the most satisfactory result.

COPPER MINING IN THE SOUTHWEST.

BY JAMES DOUGLAS.

The copper industry of southern Arizona during the year 1903 was active and prosperous. The older companies maintained their production, and of the new companies the Calumet & Arizona, the Shannon and the Black Diamond increased their output. If the two copper works in northern Sonora near the American line, whose output reaches the American market over American railroads, be included in the copper production of the Southwest, the total production during the year 1903 is approximately 80,000 tons. Of this amount about 26,000 tons is due to the production of the Greene Consolidated Copper Company and the Moctezuma Company in Sonora. The United Verde is not included; the production is supposed to be normal, and improvements at that mine aim at giving greater facilities for hoisting and handling ore, and counteracting the damage done by the fire which has for years retarded operations.

The production of the Old Dominion mine has been turned out principally in the form of high-grade matte. As the Old Dominion is erecting new smelting works with a converter department, its production in the near future will reach the market, like that of all the mines of the Southwest except the Black Diamond, in the form of bessemer bars. More radical improvements are being made by the Old Dominion, both in the mining and smelting departments, than by any other of the older companies, with a view of raising the production to approximately 2,000,000 lb. per month.

In the Bisbee district there has been great activity, some two dozen companies outside the Copper Queen being engaged in more or less active development. The only one of these companies which is increasing the Arizona production is the Calumet & Arizona, whose smelting works at Douglas have turned out approximately 12,000 tons in 1903. But another new company, the Lake Superior & Pittsburg, which bought the property of the South Bisbee Company, has encountered a large body of oxidized ore on the 1,000-ft. level, and will probably add somewhat to the production of 1904. The large Douglas works of the Copper Queen Company, recently placed in operation, will approach a capacity of 2,000 tons a day when running full, and their supply will be drawn not only from the property of the Copper Queen mine, but from the Moctezuma Copper Company's mine in Sonora, the United Globe mines, and other properties controlled by the same owners. They will also be used as custom works for the smelting of copper and dry gold and silver ores, but not of lead.

In the Clifton district the Shannon Company has almost steadily increased its output, which has attained an average of nearly 500 tons a month. The Detroit Company and the Arizona Copper Company have shown no inclination to increase their output notably. The Standard Company has been a steady producer of high-grade ore, which is handled by the Arizona Copper Company's smelter, and other mines in the same district are being developed with the probability of maintaining, if not increasing, its productiveness. The ores, however, of Clifton and Morenci, where they exist in large quantities, are so lean, and involve so heavy an expenditure in works, and the margin of profit per ton is correspondingly so small, that any rapid increase of production from that region cannot be anticipated. On the other hand, the size of the orebodies is such that no signs of exhaustion need be anticipated in the near future. The prospects, therefore, are that the contribution from Arizona in 1904 will be slightly greater than in 1903, unless operations are curtailed by labor troubles, either in Arizona itself or in the coal mines whence Arizona draws her fuel supply, or by catastrophes which one cannot foresee.

GOLD AND COPPER MINES OF THE SOUTH.

BY RICHARD EAMES, JR.

The Southern mining field during 1903 has seen two or three remarkable gold developments—the Barringer and Iola mines, in North Carolina. The Barringer produced a pocket of gold-bearing quartz and calcite that yielded several thousand dollars to the ton, and the Iola mine produced nearly $75,000 from a 10-stamp mill.

The older mines, including the Haile mine, in South Carolina; the Creighton, in Georgia; the Gold Hill, Russell, McMackin, Parker, Sam Christian, Fentress, Capps and others, in North Carolina, and one or two in Virginia, have contributed to the output in the usual spasmodic manner, until the production is in the neighborhood of $300,000.

This amount seems very meagre compared with the numerous substantial developments in the mineral belt, but the year has been given over mostly to development. In North Carolina, the Whitney Company has developed at its mines nearly 1,000,000 tons of gold ore; has built seven miles of standard-gauge railroad track, connecting the mines with the Yadkin river, and is preparing to erect a 20,000-h. p. plant. This power will be transmitted to near-by mines, towns and factories, thereby cheapening production, and will prove a great factor in working mines. The Phœnix mine, in Cabarrus county, has done fully $75,000 worth of development, the mines of Guilford county have spent most of the year in opening up new ground, and the same can be said of the Hercules gold and copper mine, at Cid. In Virginia, a promising gold mine has been partly developed near Virgilina. Mill tests have shown the ore to be worth $50 per ton.

The talc, mica, corundum and gem industries are showing some activity. A new industry is the mining and cleaning of rutile by the American Rutile Company, that has a 10-stamp mill and concentrators, and is working a deposit near Roseland, Nelson county, Va. It turns out 1,800 lb. per diem, and ships to the Krupp works at Essen, Germany.

Most of the copper output has been from the Virgilina district, near the border of North Carolina and Virginia, where are several mines that produce rich ore. Guilford county, North Carolina, has made some shipments, as has Rowan county from the Gold Hill and Union copper mines. It is estimated that these mines have many thousands of tons in sight. The Hercules mine, in Davidson county, has also developed good-sized bodies of copper ore, while several of the Cabarrus county and Mecklenburg county mines have made small shipments. Some new deposits have been opened, and the outlook is good for future production, when the ores can be treated nearer the mines.

Several attempts at smelting have been made, which may be considered successful from a metallurgical point of view, but not from a commercial. The Rodfish Mining Company, at Nelly's Ford, in Nelson county, Virginia, erected a Vulcan furnace. It makes a matte running 40 per cent copper, and ships this in small quantities. The Seminole copper-gold mine, in Georgia, has done some smelting and made small shipments.

The desultory manner in which copper mining is carried on makes it difficult to estimate the product, but outside of Ducktown copper mines I would put the output at 25,000 tons of 6 to 7 per cent ore.

A nickel deposit opened near Webster, in Jackson county, North Carolina, bids fair to be important, as does the arsenic-gold plant at Terry's Ford, Floyd county, Virginia.

BRITISH COLUMBIA.

BY S. S. FOWLER.

Gold and Silver.—The mining of gold- and silver-bearing ores in British Columbia continues to be done chiefly in a very small part of the province, namely, the southeastern corner, comprising the district of Kootenay and a portion of Yale, all of it being south of the Canadian Pacific Railway.

The following table gives the official output of the year 1903:

	Ore. Tons.	Gold. Oz.	Silver. Oz.	Copper. Lb.	Lead Lb.
Boundary district	697,284	50,508	320,749	18,485,542	23,531
Rossland	360,786	145,353	209,537	8,652,127	....
Nelson	76,923	20,214	190,003	346,218	1,072,542
Slocan and East Kootenay	14,156	1,274	1,554,474	181	10,597,948
Miscellaneous	137,027	68,503	721,441	6,875,853	6,395,262
Total	1,286,176	285,852	2,996,204	34,359,921	18,089,283

As compared with the output of 1902, there is an increase of nearly 300,000 tons of ore, a decrease of 5,296 oz. gold, and a decrease of 921,711 oz. silver. It is to be noted that the tonnage mined in the extremely low-grade district of the Boundary is 55 per cent of the total. The average ores of the Boundary are found to yield about .07 oz. gold, 0.35 oz. silver and 1.2 per cent copper. The precious metals are therefore less in value than the base.

A few small mines of this Boundary district, all in the vicinity of Greenwood, are producing quartz ores with about 4 to 5 oz. gold and 50 to 60 oz. silver per ton. Allowance for such material makes the profitable mining of the copper-bearing ores all the more remarkable.

In the Rossland district there has been a radical increase of tonnage. Here the main value is in gold, the ores averaging, as now mined, about 0.45 oz. gold, 1.1 oz. silver, and 1.1 per cent copper. Continuance of operation at the more important mines, therefore, indicates a greatly decreased cost of either mining or smelting, or both, as compared with that which prevailed only five or six years ago, when freight and smelting charges amounted to from $9 to $11 per ton.

The year 1903 has witnessed the apparently successful introduction of the Elmore process, and its success in concentrating the low-grade ores of Le Roi No. 2 mine is leading to its application elsewhere.

The Rossland Water Power Company, affiliated with the Centre Star and War Eagle mines, is now building a large concentrating plant at Trail. The completion of this will undoubtedly lead to a much increased tonnage output in the coming year.

In the Nelson district, the old Silver King mine has been successfully operated in a small way under lease, whilst the milling of free gold ores and the mining of sulphide gold ores at the smaller properties has resulted in an increased tonnage and metal output from them as compared with 1902. The net output of gold is but little less than that of 1902, but that of silver has decreased considerably.

At various outlying camps several 10-stamp gold mills have been built, but they began operations too late in the year to have any marked effect on the output. Including these plants and the older ones, the free-milling properties have crushed during 1903 about 95,000 tons of quartz, yielding in bullion 25,000 oz. gold and about 17,000 oz. silver.

Slocan, East Kootenay and the Lardeau are producers of the greater part of the silver and practically all of the lead of the province. This lead country has, for various reasons, been far from prosperous, with a consequent considerable decrease in the output of dry silver ores.

In the Similkameen river country, on the eastern slopes of the Cascades, and near Hedley City, the Nickel Plate mine, belonging to the representatives of the late Marcus Daly, has about finished a 40-stamp mill with concentrating and cyanide plants. The ore is quartz carrying arsenical pyrite, and, in gold tenor, is said to be much above the average milling ores of the country. This property may be looked to for a large output during the coming year.

Aside from the gold-milling center about Cambourne, in the upper Lardeau and Fish river, the only other district which has attracted much notice during the year is what is now known as Poplar. This camp is situated on the Lardeau river, northwest of Kootenay lake, and, although it has not yet reached the stage of commercial production, it has caused much local excitement because of the extraordinary richness of the large quantity of specimens sent out. Development is being prosecuted on several of the more prominent claims, and the coming year doubtless will have added much to our knowledge of this district, which bears the promise of becoming important.

An interesting feature of progress during 1903 has been the construction cf a 20-stamp chloridizing mill for the treatment of concentrator tailings from the ore of the Silver Cup mine in the Lardeau district. The outcome of this return to an old process will be watched keenly.

Another important undertaking is the preparation for work on an extensive scale of the Hunter V. property, near Ymir, 20 miles south of Nelson. This mine carries a belt of limestone about 200 ft. wide, which at many points is impregnated with silver minerals to such an extent as to yield about 15 to 20 oz. silver per ton, with small amounts of gold. The rock itself has a large excess of lime and is thus desirable to the local smelters. A tramway of 25 miles length has been built to the Great Northern railway, and shipments began early in 1904.

Copper.—The production of copper in the Boundary district was nearly 1,750 tons in excess of 1902.

Most of the Boundary ores are smelted at the three local plants of the Granby Company, the British Columbia Copper Company, and the Montreal & Boston Company, none of which are more than 25 miles from the mines. These three plants now have in operation ten large furnaces, whose joint daily capacity may be put at 3,000 tons. Concentration to matte proceeds in the ratio of about 40 tons into one, and the resulting matte averages about 45 per cent copper. All of the matte is converted to blister copper at the works of the Granby Company, at Grand Forks, and the products are shipped to New York for refining.

The British Columbia Copper Company is now installing two stands of converters, and it is said to be preparing to double its smelting capacity. These works are being equipped for operation by electric power derived from the plant of the Cascade Water, Power & Light Company, at Cascade, on the Kettle river.

The essentially low-grade character of these Boundary mines renders operations on a large scale necessary to success, and as the mines become further developed, the extensions of mining and smelting equipment seem certain of justification. The latest announcement of important development work concerns that to be undertaken by the Granby Company; this involves the driving of a two-mile adit intended to tap the Phœnix mines at about 1,700 ft. depth. The company also contemplates the erection of another smelting plant near the mouth of this adit, with the ultimate object of doubling the present output.

Two or more properties in this district have been added to the list of shippers during the year, namely, the Oro Denoro and the Athelstane, but the supply of ores sufficiently high in sulphur still seems to be insufficient to permit other than the high ratio of ore to matte above mentioned.

In 1902 the Boundary produced 521,402 tons of ore and 7,478 tons of copper. The development and advancement of this region is therefore evident. The Granby Company has been placed upon the dividend list.

At Rossland, beside an increase of tonnage, amounting to over 31,000 tons as compared with 1902, an important and interesting phase of the progress of the district has been the successful application of the Elmore process to the concentration of the lower grade of ores. A 50-ton plant at Le Roi No. 2 property was finished about the middle of September, and it is stated that its success has already resulted in arrangements for two other plants. Near the smelting town of Trail a concentration plant is being erected, essentially for the benefit of the Centre Star and War Eagle mines. The tailings will be re-treated by a process, the details of which have, I believe, not yet been made public, and also, in part, by the application of the Elmore process.

About 60 per cent of the Rossland output is smelted at Northport, Wash., and the remainder chiefly at Trail, although latterly a small part has been sent to Greenwood, where the Rossland ore is desirable on account of its greater content of sulphur. The haul of 140 miles and the heavy grade of railway, however, prevent any great part of Rossland ores being smelted at points so far away. At Trail much of the low-grade Rossland ore has been smelted with lead ores.

The general reduction of costs at Rossland, with lower freight and treatment rates, has afforded this district an opportunity of regaining its former strength, and now that concentration has become an efficient factor there appears to be an excellent future for the town.

In 1902 Rossland and the Boundary produced about 92 per cent of all British Columbia copper. The balance came from the mines of Vancouver Island, for which the Tyee and Northwestern companies both built well-equipped smelting plants. The production of copper in that district was 6,861,171 pounds in 1893, as against 2,496,681 in 1902.

No new copper districts have been discovered during 1903, but more or less quiet development is proceeding in the Similkameen, Nicola and Kamloops districts. Kamloops has shipped small quantities, and it is reported that arrangements are being made for the establishment of a smelting plant at that point. As far as development has proceeded in the Similkameen and Upper Nicola camps, the several important properties have proved to be remarkable, both on account of their size and high copper contents. This country is still waiting for the advent of the railway; when that takes place there will be greater stimulus to production.

Lead.—Until quite recently, and for two years past, the conditions surrounding the lead-silver mining industry in British Columbia have been distinctly unsatisfactory. The only available market within easy reach has been in the United States, but free access to it has been precluded by the tariff. The low prices obtainable by the miner for his lead (in January, 1904, $1.40 per hundred pounds), and the low value of silver, brought the British Columbia lead mines a year ago to a point at which profits vanished and the industry was fast expiring; this was evidenced by a decrease from about 36,600 tons in 1900 to 11,000 tons in 1902. An appeal for assistance was made to the Dominion government in the spring of 1903; a radical change in the Canadian tariff was asked; but instead of this, the miner had to be content with a bounty of $15 per ton for five years and limited to $500,000 in any one year, on ore mined and smelted in Canada. The decision was reached by the government in July last, and in December arrangements were finally perfected for the payment of any bounty earned.

Meantime, although silver prices became somewhat better than they were a year ago, the mines, for one reason or another, have not been very actively worked, and the result is that the year 1903 shows a total production of lead of not much over 9,000 tons. Some of this is practically a by-product and would have been produced at any price, from gold ores.

The production of lead-silver ores, as such, amounted to about 21,000 tons, containing about 8,500 tons of lead and 2,100,000 oz. silver. These compare very unfavorably with the figures for 1902, when 31,700 tons of ore containing 10,400 tons of lead and 2,928,000 oz. silver were marketed. It is noticeable that the decrease of silver is very much greater, proportionately, than that of the lead. This is mainly because of the great falling off in the production of the dry silver ores from the Slocan Lake mines. The low prices of silver and a smaller demand for these ores consequent on the decreased production of lead, is responsible for this important change.

During the period of depression, which has lasted so long, some of the lead properties unfortunately, and possibly unavoidably, permitted development work to get very far behind, and it is now undoubtedly a fact that these properties are face to face with depleted treasuries and exhausted ore-reserves. Although this remark cannot be applied to more than a few of the mines, it is, still, a condition which, together with uncertainty as to when the lead-bounty was to be available, and some professed dissatisfaction as to smelting rates or attempts at having them lessened, has produced a very gloomy year in the lead districts.

Under such circumstances, mine-owners have naturally begun to think more of the possibility of deriving some revenue from the zinc contents of their mines, instead of longer permitting that metal to be a burden on their operations. Considerable interest in the zinc-producing capabilities of the Slocan has been manifest, not only on the part of the owners, but, as well, on the part of zinc-ore buyers and the sellers of the various makes of magnetic separators. The net result of this interest in a comparatively new phase of the lead-mining business, is that about 2,000 tons of zinc ore or concentrates have been marketed, and at least one magnetic separating plant has been put into successful operation. Success in turning this hitherto baneful element to account certainly seems to be nearer, for the whole of the Slocan, than it was a few months ago. Most of the product of this class has gone to Iola, in Kansas, at a freight cost of $11 per ton. This charge is greater than the product can well stand, and the feeling is growing that ultimate success is to be reached only by the means of a reduction plant erected in the country, or else a very moderate freight rate to tidewater.

It is interesting to note that, as the result of zinc-milling, in some instances at least, the higher the grade of zinc in the concentrate the lower the silver values become. This is of importance because of the fact that in the earlier zinc shipments, containing from 40 to 45 per cent, the silver was sold at far too great a sacrifice. Effort toward as perfect a concentration as possible is to be made, therefore, and it is satisfactory to note that at the mill of the Payne mine a product of 55 per cent is now being made, with only a very low silver content. The silver minerals are supposed to accompany the magnetic tailings, which may be found to command a ready sale to the lead smelter.

At the close of 1904 there was found a decidedly better feeling in the lead camps, and it may be expected that, what with artificial assistance of the lead-bounty, the better utilization of the ores, the new 'finds' and any improvement in the prices of silver, 1904 will witness a return of former prosperity.

Excepting about 2,900 tons, all of the product of the lead mines was sold either to the Hall Mining & Smelting Company, at Nelson, or to the Canadian Smelting Works at Trail. At the latter point a new electrolytic lead-refining plant of 20 tons daily capacity was erected during the year.

MINING IN ONTARIO.

BY THOS. W. GIBSON.

The year 1903 has seen the mining industry of Ontario make considerable progress in some departments. The chief metallic products of the province are nickel, copper and iron; the principal non-metallic ones are petroleum, natural gas, salt, mica and corundum, besides building materials of various kinds.

Nickel is mined in the well-known Sudbury region, the ore being a mixture of pyrrhotite carrying nickel and copper pyrites. The principal producers are the Canadian Copper Company, which is the operating branch of the International Nickel Company; the Mond Nickel Company, and the Lake Superior Power Company. The Canadian Copper Company's operations are on a larger scale than those of the other two companies taken together. When the so-called 'combine' was formed, about two years ago, the consolidated company came into possession of several well-developed and productive mines and a large reduction plant that had grown up as the business expanded, and which was consequently somewhat out of date. The new company at once set to work to remodel the plant, and now have the new works well on the way to completion. The old furnaces of 150 tons capacity have been replaced by smelters capable of treating 600 tons per day. Other improvements have been introduced, such as mixing a considerable proportion of green, or unroasted, ore with roasted ore in the smelter charges. It is intended also to do away with the calciners in which, after pulverization, the matte is re-roasted previous to being smelted the second time, and to substitute the bessemer process, by which the low-grade matte is converted into a matte carrying 80 per cent and upward of nickel and copper. The company's mining operations are now largely confined to the Creighton mine, a huge deposit of high-grade ore in which open-cut or quarrying methods are yet carried on. Copper Cliff and No. 2 mines have also been worked; the former is now down to the fourteenth level. When completed, this company's equipment will be of a most modern and efficient kind.

At the Victoria mines the Mond Nickel Company ceased raising ore some months ago, and the workings have filled up with water. Smelting has continued for the purpose of converting all the ore on hand into bessemer matte, both from the company's own mine and from the North Star, a property held under working bond. At the company's works here and at the refinery at Clydach, Wales, a large quantity of 80 per cent matte is stored for future treatment. The financial troubles, which have proved too much for the Clergue companies, brought the Lake Superior Power Company's operations at the Elsie and Gertrude nickel mines to a close. Not much actual mining had been done at either mine for a year or so, but at the Gertrude ore-bodies of considerable size were opened up, and both properties were looking better when the stoppage came than at any previous time. All the matte produced by the smelter remains on hand.

Just before snow fell some remarkable discoveries of nickel, cobalt, arsenic and silver ores were announced from a point along the line of the new government railway, about five miles south of Haileybury, an account of which was given in The Engineering and Mining Journal by Prof. Miller, Provincial Geologist. The nickel occurs as nicolite, and the cobalt as smaltite. The latter predominates in quantity so far as known. Native silver occurs abundantly in association with the nicolite. Until further exploration takes place it cannot be said whether or not other deposits exist besides those already known, but the rocks in which the veins occur cover an extensive area. The formation is slate or slate-breccia, formerly classed as Huronian, but now suspected to belong to the Animikie horizon, and so probably equivalent to the silver-bearing rocks of the Port Arthur district. Should these cobalt-nickel-silver-arsenic ores prove to be in quantity, the deposits will undoubtedly be valuable, and their discovery illustrates anew the mineral possibilities of northern Ontario.

The output of nickel for 1903 amounted to 6,998 tons, valued in the matte at $2,499,068, which is much in excess of the production of 1902, and indeed constitutes a record production of this metal.

The nickel-copper ores of Sudbury are also the principal source of the copper produced in Ontario, but two or three purely copper mines north of Lake Huron and one west of Lake Superior now contribute their quota. The equivalent of 5,331 tons of copper was raised during the year, having a value of $716,726.

The chief producer of iron ore for the year was the Helen mine, in the Michipicoton division. This mine was the property of the Lake Superior Power Company, and as such has been shut down in the general stoppage of the Clergue enterprises. It is believed that there remains in the mine a large quantity of good ore. The Radnor magnetite mine, in Grattan township, and one or two properties in Hastings have also been worked. The total output for the year was 208,154 tons, valued at $450,099.

Coke pig iron has been produced by the Hamilton Steel & Iron Company and the Canada Iron Furnace Company, and charcoal-iron by the Deseronto Iron Company. The united product for the twelve months was 87,004 tons.

MINING IN MEXICO.

BY JAS. W. MALCOLMSON.

During the year there has been an immense influx of American capital to Mexico, due to several causes. The labor troubles in several of the principal mining camps of the United States, the fact that mine prospecting and development in Mexico requires less capital than in the regions north of the Rio Grande, and that there is a large area of territory still remaining unexplored, are some of the reasons. Most of the newer enterprises are still in process of development.

Asientos.—A notable example of successful operations in silver mining and the possibilities of a mining enterprise, even when conducted on a small scale at the beginning, is well shown at the Santa Francisca mine in Asientos, State of Aguascalientes. Here an old mine which had been full of water for one hundred years was pumped dry at a cost of less than $40,000, Mexican currency. This mine, with considerable ore in sight assaying over 45 oz. silver per ton, was found to have been abandoned, perhaps on account of one of the numerous revolutions which formerly swept over the country, or the insufficiency of the means for handling the water. Since March, 1902, to the present time, an ore-body has been opened up on this property 2,180 ft. long and 50 ft. wide, assaying 40 oz. silver per ton; a railroad eight miles long has been built to the property from the Mexican Central Railroad at San Gil; 20,000 tons of ore have been mined from development work and 500,000 tons of ore are conservatively estimated as in reserve. All this work has been accomplished at a cost not exceeding $300,000 United States currency, and a very large profit is already assured. This mine now belongs to the American Smelting and Refining Company.

Parral.—In the north of Mexico a great deal of capital has been invested in the silver mining camp of Parral; the main producers are the Quebradillas, Refugio, Santa Ana, Tajo, Los Muertos, Terrenates, Caldas and Palmillo. The well-known mine of Pedro Alvarado, El Palmillo, has maintained its production during the year, but the mine has never given more than a fraction of the wealth popularly estimated. During the past three years the Palmillo mine has produced 1,200 tons per month of ore assaying between 40 and 50 oz. silver per ton, and 0.2 oz. of gold per ton. This was worth $1,000,000, United States currency, after deducting freight and treatment charges. The net profits, after deducting cost of mining, were probably $500,000, United States currency, for the three years. Operating expenses on this property have always been higher than would have been the case had the mine been conducted as an ordinary commercial enterprise. This mine has now been worked to water-level, 600 ft. from surface. The Parral district, which affords the chief supply of silicious ores for the smelters in the north of Mexico, has suffered toward the latter part of the year, on account of an over-supply of silica, caused to a large degree by the re-opening of the Tombstone mines in Arizona; as a consequence, treatment rates have been raised throughout the district. The re-opening of the lixiviation mills is under consideration.

Many of the principal mines of Parral have now been worked down to the water-level, and require pumping machinery on a large scale to maintain production. The mines so affected are the Preseña, La Prieta, El Tajo, San Juanico, Cabardeña, Jesus Maria, Sierra Madre, and many others. The district is an old one, and maintains its reputation and output. The San Francisco del Oro mines have been transferred to an English company. Extensive development and a large installation of machinery is under way to put the mines on a dividend-paying basis.

In the Santa Barbara district the Tecolotes Company, controlled by the Messrs. Guggenheim, has operated two units of the concentrator, besides shipping a good deal of low-grade lead carbonate. This mill is operated by gas-engines, using producer gas, and is a good example of a plant with a large capacity using Bartlett and Wilfley tables. The mill of the Montezuma Lead Company was worked to full capacity most of the year. This mill uses Hartz jigs, removing most of the lead; and the gold-bearing tailings are re-ground in seven Monadnock Chilean mills. The capacity of the mill is 450 tons per day. The magnetic separation of a zinc-blende free from precious metals has been satisfactorily effected here. The mill middlings, containing 25 per cent zinc, are made into a 50 per cent zinc product, while the lead, iron and copper from the magnetic separation are shipped to the San Luis Potosi smelter. The Alfereña Mining Company is now grading for the erection of a 150-ton concentrator. A main adit, the El Toro, is being pushed to open up the ground acquired by the No. 2 smelter of Monterey. During the year the Torreon smelter has secured mines in Santa Barbara, and the erection of a concentrator is now under consideration.

In Amaloya, the Cigarrero mine is producing 2,500 tons monthly of high-grade silver-lead carbonates, carrying some gold. This ore was found only a few months ago, but there is already a large tonnage in sight. This is a new district, and is now being rapidly developed. The silver-lead carbonate deposits in the Cretaceous limestones of northern Mexico are steadily increasing in importance, and nearly every year finds a new mining camp to its credit. Prospecting in these northern deserts is difficult, on account of the absence of water, supplies and labor, but there is no doubt that many more deposits will be found. Among the districts now being exploited may be mentioned the Sierra Mojada, Santa Eulalia, Mapimi, Monterey, Villaldama, Terrazas, Minillas, Naica, Muzquiz, Cerralvo, Carmen, Velardeña, Amaloya, Vacas and Norias de Bajan.

Santa Eulalia.—In the Santa Eulalia mines, near Chihuahua, a uniform output of leady ores has been maintained during the year. The ore-shoots of this district are of enormous size, being over 1,000 ft. long, 200 to 400 ft. wide, and over 900 ft. in vertical extension, and still continuing downward. The problem of supporting the ground has always been a difficult one, and a number of very disastrous caves have characterized the history of ore extraction in this camp. During 1903 the caving of many thousands of tons of lead carbonate ore in the old Santo Domingo mines caused some uneasiness, but, happily, occurred without loss of life. One of the largest ore-bodies in the camp is being mined without any supports at all for the roof, and the hole which is gradually being opened out is one of the sights of the district. This camp has always suffered from lawsuits regarding titles and side-lines, and 1903 has been no exception to the rule.

In the Sierra Mojada the tonnage mined is diminishing, and the grade of the ore shipped lower than during any previous year, although some new strikes of importance were made in the Fortuna and Fronteriza mines. It is only due to the fact that the smelting companies need these leady and lime ores to run their plants that mining operations are maintained at their present level in this district. The smelting industry has helped the mining business to a remarkable degree in the north of Mexico. As a rule, the northern ores cannot be treated in mills without considerable loss of value, and the extension of smelting enterprises has enabled mines to be operated at a profit with a comparatively small investment which formerly could not be handled at all. It is estimated that ten years ago 85 per cent of the total ore mined in Mexico was treated at the mines with a loss of 20 per cent of the contents. To-day 85 per cent of the ore mined is shipped to smelters, and the loss in treatment is less than 5 per cent. The miners are not required to invest heavily in milling plants, and very much larger profits are made.

Ocampo.—A typical illustration of the old method is still to be seen in the Jesus Maria, or Ocampo, district, in the State of Chihuahua, a camp which railroads have not yet benefited. In this district there are dozens of good mines carrying high values in gold and silver, and when the camp is reached by a railroad it will become one of the most profitable in the country, as most of the ore now being indifferently treated in local mills will be shipped to the smelters. In the Sierra Madre range the gold-silver properties are steadily receiving more attention. The purchase of the Dolores mine by the Mines Company of America, in conjunction with English capital, will probably stimulate development in the surrounding country. At the Dos Cabezas mine, north of Dolores, a concentrating plant has just been introduced, but the owners are apparently still hesitating as to the method of handling their high-grade gold-silver tailings.

Lluvia de Oro.—Along the proposed route of the Kansas City, Mexico & Orient Railway a very remarkable gold prospect, the Lluvia de Oro, has been taken up by Los Angeles capitalists. The ore is found as a series of quartz outcrops in limestone, without any very well-marked strike or dip, except for short distances.

The gold content of these quartz enrichments is very high indeed, being in some places as much as 11 oz. per ton. A general average sample of all the quartz exposed when the company started work showed 3 oz. gold per ton. This property has been described as the best prospect in America, and the present operators have a chance to open up one of the great gold mines of the world if the outcrop values are maintained in depth.

Baquerachic.—Near the Lluvia de Oro property, and in the same limestone formation, a copper deposit, the Jesus Maria de Baquerachic, only needs railroad facilities to make it a producer of importance. The ore is copper sulphide, carrying 5 oz. of silver and 0.1 of an ounce of gold per ton. The property has been known for many years, and figured in the war of the French intervention. Several thousand feet of development work has been done in the decomposed contact matter where the deposits are found, but until quite recently the workings have been inaccessible, owing to rotten timber and consequent caving ground.

Mapimi.—In Durango, the Peñoles Mining Company, at Mapimi, has maintained its output, and seems to have overcome its difficulties with the sulphides and arsenic found in the lower levels of the mines. This material is now about to be handled by the Huntington-Heberlein process, which consists mainly of a forced draught through the red-hot ore, oxidizing and carrying off the greater portion of the arsenic and sulphur, leaving the resulting product sintered and in excellent condition for the blast-furnace. At Velardeña a railroad has been built, 22 miles long, to the copper mines, and large expenditures are being made by the Guggenheims and the American Smelting & Refining Company in a power-plant, concentrator, etc. It is not improbable that the smelter will be entirely remodeled and operated again. The Descubridora Copper Mining Company, near Conejos, on the Mexican Central Railroad, has shut down its smelting plant temporarily, and is doing extensive development in the mines. At Tejamen, the silver mines of Mr. Octaviano Cornejo have been closed down, and the town has been almost depopulated. At Tepezala, in Aguascalientes, El Cobre property has ceased shipments of ore, pending further development. The Fortuna and other properties have made a good showing during the year.

Zacatecas.—The Veta Grande mine has maintained a regular production of high-grade silver ore. The San Rafael mines of the Stilwell corporation are in full operation. The Mala Noche mines are being operated by G. C. Palmer, and it is reported that the American Smelting & Refining Company is backing the enterprise.

Concepcion del Oro.—Mining operations have been somewhat more active in this district. A branch of the Coahuila & Zacatecas Railway, from Avalos to San Pedro de Ocampo, has been built, and the mines, which carry lead and copper as well as silver and gold, will probably be more extensively explored and developed during the ensuing year.

Guanajuato.—An immense amount of mining exploration and development has been accomplished. A very extensive electric power plant has been inaugurated, and mill construction has gone forward on a large scale. The coming year will no doubt see very profitable results from these enterprises. The camp of Pachuca has maintained its usual production, and numerous new ore-strikes are reported.

At Tezuitlan, State of Puebla, considerable prospecting has been done, but so far the ore-body of the Tezuitlan Copper Company seems to be the only deposit of importance in the district, although some good ore has been found at Zautla carrying copper, silver and gold. The best mine there, the Armando, seems to have a very promising future. The camp of Tetela de Oro also has received considerable attention. At Tezuitlan there are two Herreshoff furnaces in operation, which smelt the roasted ore. The ore treated is roasted in stalls, and assays 7 per cent copper, 4 oz. silver and 0.03 oz. gold per ton. Fifteen tons of copper are bessemerized daily, and the zinc contents, 10 per cent, are entirely eliminated.

At Ocotlan, in the State of Oaxaca, there was great excitement during 1903, on account of some phenomenally rich gold-quartz outcrops which were found, but the district as a whole has not held its own, and it is very much handicapped by the long distance and the high freight rates to the smelters, together with the unsatisfactory character of silver-gold milling, as conducted locally.

El Oro.—Gold mining has been most successful during 1903 in the mining district of El Oro, State of Mexico, and its extension toward Tlalpujahua, in the State of Michoacan. El Oro Mining & Railway Company made probably the best record of any company in the Republic. Mining in this district is stimulated on account of the large profits in sight and the fact that gold is produced by silver-paid labor. El Oro mine has immense ore reserves, there being over 600,000 tons of ore blocked out in the mine, and very much more practically proved and in process of development. In addition to this, there is a large area of unprospected ground in the property. During 1903 El Oro Mining & Railway Company took up the adjoining properties, the Somera and the Mexico, and regular profits are now assured at the rate of $1,000,000 annually. The adjoining mine to the north, the Esperanza, with reserves capable of yielding a net profit of $2,000,000, United States currency, has been secured by the Messrs. Guggenheim. Not very far from these properties, in the Dos Estrellas mine, which was merely a prospect two years ago, there have been discovered and opened up enormous bodies of high-grade silver-gold ores. Two veins have been cut in bonanza, and an 80-stamp mill and cyanide plant have just been put into commission. If this mine continues its developmet for another year as it has done during the past 12 months, it will be one of the great mines of the country. The mines of this district are quartz-veins in shale, covered by an andesite capping of some thickness, and a large number of properties are being exploited with the object of discovering and exploring veins below this cap. Although most of these properties are still without any definite outlook, a very large amount of exploration is being carried on in this ground, and it is probable that some of the operators will succeed in developing dividend-paying properties.

Cananea.—The successful development of the copper deposits in the north of Sonora has gone steadily forward. The Greene Consolidated Copper Company increased its production to 325,000 tons of ore and 130,000 tons of flux, while the production of metallic copper at the beginning of 1904 was 60 tons per day. The grade of the ore handled is not so high as during 1902, and concentrating machinery that will handle over 50,000 tons monthly is under process of construction and improvement.

Nacozari.—The mines in this district are reached by a new railroad, and on the completion of the new smelter at Douglas it is probable that the Nacozari concentrates will be shipped to that point for smelting. Considerable attention has been given during the year to the copper region on both sides of the Yaqui River, but so far no mine of importance has been opened up. A number of smelting enterprises are under way, and the results of mining development are very encouraging, but the absence of transportation facilities is a serious drawback to operations there. This is the chief hindrance to successful mining in southern Sonora, but where high-grade ore is mined or rich concentrates produced, such as those at La Bufa and La Dura, excellent results are obtained. A very promising mining country is being opened up by the Phelps-Dodge railroad, from Douglas to Nacozari, and many mines in this neighborhood have made a very good showing during the year.

THE EASTERN STATES OF AUSTRALIA.

BY F. DANVERS POWER.

Queensland.—The output from the Queensland gold-fields has been very good this year, and in certain cases new records have been made. The gold production was 668,546 oz. fine, being an increase of more than four per cent over 1902.

Charters Towers has a greater number of assured profit-making mines than formerly, and is the most promising field in this State.

Gympie made its record monthly yield in September. As examples of how these mines pay, we may mention No. 2 South Great Eastern, with 144,000 shares which have been paid up to 4d. each; this has paid 11 dividends during the year, totaling 14s. per share; the South Glanmire & Monkland, with 120,000 shares paid up to 2s. 11d. each, has also paid 11 dividends, which totaled 10s. 9d. per share. The West of Scotland mine has a shaft which boasts of being the deepest in Queensland, it being 3,069 ft. deep, with good ore at the bottom.

Croydon shows signs of a revival, a larger number of mines being productive than for a long time past.

At Ravenswood, now over 30 years old, the Politician paid a dividend.

Mount Morgan has kept up its regular monthly dividend of threepence per share, amounting to £137,500 for the first 11 months of the year. The dividends paid by this mine from 1886 to the end of the last half year amounted to £6,229,166. Over 20,000 tons of ore are treated per month; this is in two classes, the oxidized and the 'mundic.' The latter is the ore now principally used, and had an average grade for the first part of this year of 10.62 dwt., equal to 42.17s., or 14s. less than the average for the preceding year. The cost of mining and treating this is 26.93s. Much of the ore in the lower levels contains 2 per cent copper as against 1 per cent in the upper levels. The grade of the oxidized ore was 12.52 dwt., equal to 49.73s., or 8.12s. more than the average for the previous year, and it cost 14.73s. to mine and treat. Very satisfactory developments have taken place at the 750-ft. level, which has given an increased lease of life to this mine. A steam-shovel is being used to remove the over-burden and lay bare ore that will pay to work by open-cut, but would not pay to mine by underground methods. Some excitement was caused in the township of Mount Morgan by the discovery of gold by some boys while sinking a well in a back yard. This resulted in a portion of the township being pegged out, but the find did not amount to much, so in a few days matters resumed their ordinary aspect. There was also a small rush to the Dee River, near

Mount Morgan, but this, like so many other rushes in other parts of Australia during the year, proved a "duffer."

The New Chillagoe Railway & Mines Company, raised on the ashes of the original Chillagoe Railway & Mines Company, started work in the early part of the year and has been working ever since. The company is now about to erect a converter plant for the copper matte.

The Mount Garnet Freehold mine has had to close down as being unprofitable. The Smith's Creek and Stannery Hill tin mines also have not come up to expectations.

New South Wales.—The following are official figures showing the general production of this State for the year 1903:

Product.	Quantity.	Value.	
Silver ingots and matte................Troy ounces	1,099,373	£1,501,403	$7,507,015
Silver-lead, concentrates and ore...........Long tons	349,064		
Copper, ingots, matte and ore..............Long tons	9,201	431,186	2,155,930
Tin, ingots and ore.......................Long tons	1,298	124,893	624,465
Coal ....Long tons	6,354,846	319,660	1,598,300

There was an increase in coal, copper and tin, and a decrease in silver, lead concentrates and ore, as compared with the previous year. The above figures are for metals and minerals produced in the State, and do not include imported ores. The gold output was 254,260 oz. fine, an increase of 93,005 oz. over the total for 1902.

Gold dredging has found its level in this State. The eleven companies at work produced 27,237 oz. fine; only five of them have paid dividends, aggregating £21,700.

Beach mining has taken a fresh lease of life in the Wardell district, where several parties have pegged out claims during the year. At Nerrigundah, which is rather a patchy field, several rich finds have been made. Attention has been paid to the old Hillend gold-field of late; one mine has recently been floated, and is at present in good ore. Some cheap mining and gold treatment has been carried out at the Homeward Bound mine, Yalwal, where the average returns on 2,273 tons of ore treated during five weeks was 1½ dwt. per ton; the recovery was 23 grains by amalgamation and 13 grains by the cyanide process, the entire cost of mining, milling and cyaniding being under 5s. per ton. The English-owned Gallymont Gold-fields Company has been wound up, after an unfortunate history so far as the English shareholders are concerned. Some of the saddle reefs at Tucker's Hill, Hargraves, are turning out well. The Mount David gold mine, after being in existence for a good many years, has paid its first dividend. The Australian Gold Recovery Company has purchased the tailings of the Aladdin and Wentworth companies at Lucknow and those of the Eleanora Company at Hillgrove; at both places cyanide plants have been erected to treat the tailings.

The great event of the year at Broken Hill was the rise in the price of lead, which enabled some of the mines that were practically closed down to re-start, and those that had kept going on a reduced scale to increase their output. During the depression only the Proprietary and the South Broken Hill mines were able to pay dividends, while only two others, the Central and Block 10, continued to produce. The mines which shut down included Block 14, British, Junction, Junction North, and the North Broken Hill; of these, the British was the first to start work. Scarcely had the Hill commenced to look like itself again before the drought made itself felt to such a degree that, for the first time in the history of this field, all the mines had to be closed down temporarily, thus affecting 5,260 men employed, in addition to their wives and families and the local business people. The failure of the Stephen's Creek water-supply came as a surprise to most of the inhabitants, who were entirely unprepared for such a contingency. On account of the isolated position of Broken Hill, from which only those who had means could afford to escape, the government had to come to the rescue by providing relief work for the unemployed, arranging for water trains, and even had to provide free food for those who were hard up. The Proprietary promptly took measures to re-start work by erecting a large condensing plant, and pumping water from the old Potosi and Cosgrove shafts three miles away, so that soon a large number of the old employees were at work again. Until sufficient water could be had to re-start concentrating the ore, the Port Pirie works were kept going with material from the sintering works, ore on hand, and ore mined from the carbonate stopes. Block 10 and the Central mines were able to work part time with the help of water delivered by trains. Owing to the subsequent heavy rains, there are now twelve or fifteen months' supply of water on hand.

At the Proprietary mine the method of stoping broken ground by the cross-cut system, recently introduced, has been found satisfactory. The Delprat process for separating zinc from the lead ores has proved a success, and consequently the plant has been increased so as to have a capacity of 1,000 tons per week. The Huntington-Heberlein process has also been very satisfactory; the present plant is capable of treating 2,500 tons per week. The extraction of ore from the open cut has practically ceased, the economic limit having been reached. The lode has been cut at the 1,000-ft. level; this is an event which adds greatly to the life of the mine.

The Queensland Smelting Company has taken over the control of the Pinnacles mine. The Mechernich magnetic separator plant erected at the Central mine has been doing good work. The Australian Metals Company has erected several Ulbrich separators at West Broken Hill, so as to treat the heaps of tailings and middlings that they have bought.

The Conrad Silver Lead mine and the Conrad South Blocks have been amalgamated and floated as the Conrad Consolidated Mines, Limited, and are under the management of Mr. John Howell. This mine is a large producer of stannite, for which satisfactory returns could not be obtained from custom works; so a plant has been erected for its treatment on the spot, the products being copper matte and tin-lead bullion.

The Great Cobar copper mine, which was under offer to a London syndicate, did not change hands, but the tributers who were also large shareholders have arranged to buy out the old company so as to have sole control. The Lloyd Copper Company at Burraga, which used to smelt its ores to a matte at the mine, and send this to Lithgow for further treatment, now brings the matte to blister copper at the mine, and only refines this at Lithgow. The Crowl Creek copper mine in the Nymagee district is developing well, and reverberatory furnaces have been erected at the mine for treating the ore.

A fair amount of molybdenite has been turned out from the Kingsgate mines during the year.

The New Wylie Creek dredge is the first dredge of the bucket type erected in New South Wales for working tin gravels that has paid a dividend; but the so-called hydraulic dredges at Cope's Creek near Inverell have paid dividends.

The Malacca diamond mine, near Inverell, has started work again. A syndicate has been formed to work the Walcha graphite deposits; an asbestos property at Gundagai has also been started. The Great Australian Quicksilver Mining Company at Yulgilbar has produced the first quicksilver in bulk obtained in this State.

The finest specimen of first-class opal ever discovered at White Cliff was found in February, 20 ft. below the surface. The opal portion of the specimen weighed about 22 oz. and is reckoned to be the largest piece of first-class opal in the world. Another splendid find was made in October, when one gem was unearthed weighing 21 oz. and another 14 oz. Opal has lately been found at 73 ft., which is the greatest depth at which it has been found on this field.

The Caledonian Coal Company has proved a seam of bituminous coal on its property at Cessnock, near Maitland, 31 ft. thick, the bottom being at a depth of about 300 ft. from the surface. This is the same seam as that worked at the Pelaw Main and other collieries in the Maitland district, only it is thicker. The Sydney harbor colliery has reconstructed and is now continuing the sinking of the Jubilee shaft for ventilation purposes; this has to be done before the opening up of the seam at 2,880 ft. can be continued.

The Industrial Arbitration Act now in force, which was intended to avert strikes, has not been successful in that respect, for miners, especially those connected with coal mines, have gone out in spite of it. They put the employers to as much trouble and expense as possible, and then when the law is about to be enforced they ask to be taken back, relying on the employers doing what they require rather than let the mine remain idle longer. The act has also been used in a way not intended by the framers, as the employees of most mining districts have seized the opportunity of applying to the Arbitration Court for a raise in wages and shorter working hours, which, if granted, in many instances would necessitate the closing down of the mines, thereby doing the workers more harm than good.

Victoria.—Victoria is still the largest gold producer of the eastern States, having yielded 767,351 oz. fine gold last year, or 46,485 oz. more than in 1902.

The yield from the Bendigo gold-field is improving, as shown by the figures for the first three quarters of this year: First quarter, 46,358 oz.; second quarter, 55,589 oz.; third quarter, 61,529 oz.; fourth quarter, 22,222 oz. During this period £216,622 has been paid in dividends. The October yield is the largest of any month since December, 1875. The mines on the New Moon line of reef have been the most productive on the field, the South New Moon being the largest gold producer in Victoria. The New Chum Railway has struck free gold at the greatest depth gold has ever been found in Australia, viz., at 3,876 ft. The Victoria Quartz mines, also on the New Chum line, have cut gold-bearing 'stone' at 3,814 ft.

The Long Tunnel Extended, at Walhalla, has paid off its debit balance, and is now the second largest gold-producer in Victoria. The Long Tunnel Company is sinking its new shaft to a depth of 3,500 ft. The first 955 ft., which was sunk in two sections, was sunk at the rate of 38 ft. per week, which is a record for Australia.

Of the various small rushes that have taken place in several parts of Australia during the year, that of Waanyarra, near Tarnagulla, appears to have been the chief. The lead is narrow, but some fairly large nuggets have been obtained. Mining was delayed for a time owing to the workings having been flooded by a thunderstorm.

The work of developing the Victorian deep leads in the Loddon valley is being proceeded with. The electric plant of the Deep Leads Transmission Company, Ltd., which supplies the necessary electric power to the Charlotte Plains Consolidated Gold Mines and the Junction Deep Leads of Victoria, Ltd., is the finest of its sort in Australia owned by a private company.

The miners of the Outtrim, Howitt, Coal Creek and British & Jumbunna Collieries, in south Gippsland, again went out on strike in the early part of this year, former clemency on the part of the mine owners having been unappreciated. The latter, getting tired of these constant strikes, employed non-union men, and the mines are now working satisfactorily.

An organized strike of the railway employees of the State took place in May, which for the time being paralyzed trade, but the government made a firm stand, and the strikers were badly beaten after a struggle of a week. The strike leaders and those who took an active part against the authorities were the chief sufferers, as they lost their positions and pensions, and though some of them went to South Africa to find fresh employment, they soon discovered that strikers were not wanted in that country, so have since returned.

South Australia.—The rush which took place to the Arltunga gold-field at the early part of this year proved to be disappointing, both to those who proceeded there and to those who joined syndicates with the object of taking up properties. This is another instance of distance lending enchantment. There were many contradictory reports at first, and those who did not unduly praise the field were blamed by others as if the adverse reports had driven the gold out of the 'stone.' There was produced during 1903 22,269 fine oz. of gold, or 1,813 oz. less than in 1902.

At Kangaroo Island, south of York Peninsula, the Aororangi Gem Company of Adelaide is mining for the precious varieties of tourmaline. Stones of various shades of green, blue, lilac, pink and red have been found.

The phosphate deposits opened up at Clinton, Robertstown and Burra have not proved so good as was at first expected, owing to the large percentage of phosphates of iron and aluminum present. The phosphate is, however, still being mined and sent to the Wallaroo works for conversion into superphosphates.

The government geologist has made an unfavorable report on the Meningie oil country, and concludes that the oil found in the Coolmasson well must have been introduced from outside sources.

The South Australian government has not been fortunate in the working of its metallurgical plants. It has cyanide plants at Mt. Torrens, Petersburg, Tarcoola and Arltunga, and copper smelters at Port Augusta and Port Darwin. Each of these has proved unprofitable, and has been worked at a loss.

Tasmania.—The Tasmanians propose to make an alteration in their mining laws which should have the effect of encouraging capitalists to invest their money in the mines of this State, as they will have a better security of tenure than formerly. So far, all the Australian States insist on certain labor covenants being fulfilled, in order to insure that a lease will be continuously worked. It is now proposed to substitute a minimum expenditure per acre per annum, and to allow money actually spent on mining, whether on labor or machinery, to count; and, within certain limits, the money spent in excess during one year can be carried forward to the next. This prevents men who go on strike, and will neither work themselves nor allow others to work, applying for a forfeiture of the lease on account of the non-fulfillment of the labor conditions in their endeavor to force the hands of the mine owners. The Victorians are wisely proposing to insert a similar clause in their act, and no doubt the other States will eventually be forced to do likewise later on.

The Mount Bischoff mine continues to be a consistent monthly dividend payer. There are 12,000 shares in this mine, and during the first ten months of this year ten dividends of 7s. 6d. each have been paid, amounting to £3 15s. per share.

The Tasmania mine at Beaconsfield, the premier gold mine in Tasmania, which has lately been the subject of several abortive negotiations, has finally been sold to English capitalists.

What is supposed to be the missing Loane's reef has been picked up in the New Golden Gate mine, Mathinna, south of the slide, showing a good width of payable ore. As this reef has not been worked south of the slide between the 1,600-ft. level and the surface, the find is likely to be of great value to the district.

Osmiridium has been discovered and worked in the creeks of the serpentine country between the Huskinson and Wilson rivers in the neighborhood of Zeehan.

The low-grade argentiferous lead-zinc properties of the Magnet Silver Mining Company and the Hercules Gold & Silver Mine have succeeded in reaching the dividend-paying stage this year. The companies have not succeeded in finding a suitable process for treating their ores, so still sell them to custom works.

The Western Silver mine, situated at Zeehan, has been sold in London this year, and after having been closed down for a time, has re-started work.

The consolidation effected during the year of the Mount Lyell Railway & Mines Company with the North Mount Lyell will prove of benefit to the shareholders of both companies. The former company has a large low-grade copper proposition of basic ore, while the latter has richer but silicious ore, so by blending the two and treating them at the Mount Lyell smelting works, which are more conveniently situated than those of the North Lyell, great economies are effected, and it is hoped that under the guidance of Mr. Sticht the disputes and mistakes that have characterized the management of the North Lyell in the past will now cease. On account of the large number of shareholders consequent on the consolidation the directors have decided to pay dividends half yearly instead of quarterly, as formerly. When these two properties were fused into one, notice was given that a uniform rate of wages would be paid for a similar class of work on both mines, which meant that in some instances the current rates at the North Lyell would be somewhat reduced. A meeting of the men affected was held, and a strike threatened, but eventually better counsels prevailed. The capacity of the furnaces has been increased, and the fuel consumption decreased, thus reducing the working expenses and permitting the utilization of ore of a lower percentage in copper than formerly. The electrolytic power plant has been extended to the reduction works, thus effecting further economies.

MINING IN WESTERN AUSTRALIA.

BY A. G. CHARLETON.

Gold mining in Western Australia in 1903 presents a record of steady progress, as evidenced by increased yield and dividends, additions to treatment plant, and lower working costs; moreover, some important deep-level developments and discoveries have been made, and the industry has reaped the benefit of the efforts made by the Chamber of Mines for the improvement of the laws and regulations relating to mining.

Production.—The production of gold from 1886 to June 30, 1903, comprising both the gold entered for export and that received at the Perth branch of the Royal Mint, has amounted to 10,196,222 oz. of bullion, representing 9,903,795 fine oz., valued at £42,068,645.

The product for the past four years has been as follows: 1900—bullion 1,580,950 oz., fine gold equivalent 1,414,311 oz., value $29,236,034; 1901—bullion 1,879,390 oz., fine gold equivalent 1,703,416 oz., value $35,212,300; 1902—bullion 2,177,442 oz., fine gold equivalent 1,819,308 oz., value $37,605,-096; 1903—bullion 2,436,311 oz., fine gold equivalent 1,979,299 oz., value $40,462,252.

From 1896 up to February 29, 1904, some 10,039,807 tons of ore have been mined and treated, and the bullion yield per ton has been remarkably constant, as well as exceedingly high; averaging 1.5 oz. in 1897; 1.28 oz. in 1898; 1.31 oz. in 1899; 1.14 oz. in 1900; 1.15 oz. in 1901; 1.1 oz. in 1902, and .906 in 1903; which, considering the quantity of ore treated, may be considered phenomenal. In certain districts the average of the ore is much higher than these averages, but in such cases the tonnage is small.

The value of the gold bullion of the State was officially estimated in 1900 at £3 16s.; in 1901 at £3 17s.; in 1902 at £3 13s., and in 1903 at £3 12s. per oz. The average fineness of Western Australian gold bullion in 1902 was established at 0.8432.

The excessive cost of living, due to heavy freight rates, storekeepers' profits, and other causes, no doubt justifies the high rates of wages; but it is fortunate that nature has endowed the State with exceptionally rich ores, otherwise the scope of employment in gold mining would be more limited than it is, and there can be no doubt that with lower wages and cheaper freight rates, many low-grade mines, which cannot at present be made to pay, would be worked at a profit, to the advantage of the industry as a whole, by bringing more capital into the country and extending the field of employment.

The report of the Chamber of Mines of Western Australia, May, 1903, gives an interesting comparative statement of current wages paid in different districts, as fixed by the Court of Arbitration of Western Australia; rates of wages previously paid; the hours of labor worked; the overtime rates to be paid; and the prices of food stuffs. This instructive table shows in many instances a considerable rise in the rates formerly obtaining; but, owing to the reasons just given, it is open to question whether this will tend to the advantage either of the mine operatives as a whole or of the industries of the State, as it must tend to check rapid development by restricting the profits of the capitalist, who can invest his capital to better advantage elsewhere, than in working propositions rendered unpayable by high local costs.

The following rates of wages obtain at Southern Cross, where they are lower than on any of the other fields: Rock-drill men, 11s. 8d.; assistants, 19s.; miners and timbermen, 10s.; bracemen, platmen and mullockers, 9s.; engine-drivers and tool-smiths, 12s., and laborers 9s. per day.

At Kalgoorlie, machine-men in 'dry ground' are now paid 14s. 4d.; rising in dry ground, 13s. 10d., driving, cross-cutting, stoping or winzing in dry ground, 13s. 4d.; rock-drill assistants, brace and platmen get 11s. 8d.; mullockers and shovelers or truckers shoveling, 10s. 6d.; trucking from shoots, 10s.; timbermen, 13s. 4d.; engine-drivers, 13s. 4d.; surface laborers at cyanide vats, 11s. 8d.; other laborers, 10s. On most of the other fields the rates are considerably higher.

Gold is very widely distributed over the State, about 332,773 square miles being proclaimed as auriferous, but a large portion of this area has scarcely been prospected as yet, and so much of it is covered with alluvium and ironstone gravel that a chance accident may at any time lead to a rich find and the opening up of a new gold-field, as was the case with Kalgoorlie. Only about 2,000 sq. miles, held at various times under lease, can be said to have been carefully examined and prospected. Kalgoorlie produced about 52.83 per cent of the total gold output of the State in 1902, but only possessed, I believe, 7 per cent of the total number of properties making returns. The largest number of producing mines possessed by any one district is 9 per cent; consequently it is not a one-camp mining country, as it is frequently assumed to be.

Some 2,424 leases were held in 1902, notwithstanding the onerous labor conditions and rent, one man being required by law to be employed for every six acres, while the government rental is £1 per acre. If, however, it be assumed that each lease averages 20 acres, this, without allowing for 'exemptions,' would only give assured employment to about 8,080 men, if work were simply limited to the requirements of the law. These labor requirements press most hardly in cases where a large sum has been expended on a property without finding payable ore, and also where ore exists which might in course of a few years be worked at a profit, with cheaper communication and under improved local conditions.

The mines of Western Australia, as Mr. H. C. Hoover has observed, may be divided into four groups:

1. Leases and prospects absolutely without equipment, and of uncertain value. Many mines of this class are producing some gold by custom milling, and they contribute at present about 11 per cent to the output of the State. "A total of 1,220 of such properties produced ore in 1902, and fully 1,800 were being actually worked."

2. Small mines possessing mining equipment, which are more or less regular producers, but whose future is entirely prospective. "Of these there are 85 now contributing 11 per cent of the total output of the State."

3. Mines of medium size producing ore regularly at a profit, or in course of development, preparing for advancement to the 4th group. "There are 13 mines of this class now contributing 12 per cent to the total output of the State."

4. Large proved properties demonstrated to be sound mining concerns ranking among the large gold mines of the world. "Of this group there are 16 which are now (1903) producing 63 per cent of the total product of the State,"[1] and they may be credited with 62 per cent of the total gold production of Western Australia in 1902. This group treats about 100,000 tons per month, and in the near future will, I believe, be able to deal with some 112,000 tons monthly, their production having gradually risen from about 41 per cent of the total output of the State in 1898.

In the middle of 1903 they produced about 123,000 oz. of bullion, representing 104,153 oz. of fine gold per month, valued at £442,000.

In 1902 these 16 mines paid £1,330,327 in dividends, or 93 per cent of the total paid by the public gold mining companies of Western Australia, but this represented only a portion of their profits, as very large amounts (upwards of £1,750,000) have been spent on equipment and development since the commencement of operations, and so deducted from their profits. When the plants in course of erection are running, Mr. Hoover anticipates that the dividends of all groups will reach over £2,100,000 per annum, and he presents some very interesting calculations with a view to showing their average value per foot of depth. Adding the total output to the reserves, he reckons that above an average depth of 826 ft. there is and has been 6,223,030 tons of ore containing 7,757,037 oz. of fine gold, of a value of £32,780,399, and these mines are only at present exhausted to an average depth of less than 425 ft.

Figuring upon the sulphide ore, he concludes that each foot in depth represents, on the average, 7,100 tons[2] containing 8,270 oz. of fine gold, valued at

1 Three per cent. of the total output comes from alluvial and specimen gold.

2 If the oxidized ore was included with the sulphide ore, the average would be higher, and Mr. Hoover estimates it at 7,534 tons per foot of depth, containing 9 391 oz. of fine gold. valued at £39,688; but this is due partly to 'superficial enrichment' and partly to the greater width of the orebodies in the oxidized zone, which extends to a depth of 150 to 300 ft. from surface.

close upon £35,000, representing, roughly, £23,000 profit per foot in depth. This figure of profit appears, however, to be based on what I should regard as a low average to take as representative of present working costs; calculated upon this basis, I should not be disposed to look for a larger profit than £14,613 per foot in depth; but as working costs are constantly being reduced by increased economies, the actual figure probably lies between these two extremes.

Treating 112,000 tons per month, Mr. Hoover figures that 177 ft. of depth will be exhausted per annum. An average of 400 ft. in depth of development per annum would, therefore, suffice to open up sufficient reserves to warrant doubling their present output, which Mr. Hoover estimates should raise the gold production of these mines to over 2,000,000 oz. annually; such an output he reckons would only exhaust them to 4,000 ft. in depth in 13 years. It is possible, however, that an increased output may lower the grade of the ore, as has so often happened in other cases, unless a very large amount of ground is blocked out in advance; and it may be the best policy to do so.

Speaking generally in regard to this group, the probabilities are in favor of their permanency to a great depth; and developments show that down to 1,700 ft. from surface, the value and amount of ore developed is fully equal to that in the sulphide zone already stoped out.

It has been estimated that the 16 mines referred to produced 62 per cent of the gold output of Western Australia in 1902; and it is noteworthy that, while they paid £1,330,327 in dividends, the remaining 1,317 mines, producing about 35 per cent of the gold output, only paid £93,945.

It would appear, therefore, that the working costs of the principal group are very much lower, as might be anticipated, than those of the other three groups, because they are working on a much larger scale, and Mr. Hoover apparently figures their costs at an average of about £1 14s. per ton, in making the calculations previously given, or between 8 and 9 dwt. of fine gold; while he states that "the possibility of at present working 7 dwt. ores" has been demonstrated, that is, in the case of the free milling ores, like the Great Fingall. This has doubtless been largely brought about by improved management, resulting in the adoption of labor-saving appliances and other economies.

As regards mining at Kalgoorlie, the chief features of the year 1903 on the western side of the field have been: (1) The improvement in the position and prospects of the Associated Gold Mines. (2) The developments in the Oroya Brownhill, in following the remarkable chimney which has continued, from its outcrop in the Brownhill, through the Associated Northern Blocks and across the Oroya (North) lease almost to its southern boundary, and which is estimated by Mr. H. Daly to be worth £1,491 per foot in length, or £9 3s. 11d. per ton, while the addition to ore reserves and increased output of the Kargurli may also be noticed in this section of the field. (3) In the center of the "golden mile," the yield of the Perseverance, which reached as high a monthly total as 17,940 oz. in August last, with an average of 2.62 oz. of bullion per ton, and the improved position of the Lake View, are satisfactory features in the general progress of the field. (4) On the east side of the Boulder area the proving of the lode in the Great Boulder Proprietary by a bore-hole at a depth of 1,750 ft., 27 ft. west of the shaft. (5) The recent discovery of the lode in the Ivanhoe South Extended, by diamond drilling, at a depth of 1,920 ft. vertical, showing 4 ft. of ore assaying 1 oz. 15 dwt. per ton, is an event of importance. (6) The developments in the Ivanhoe and Golden Horseshoe, which have proved the existence of very large reserves of ore, and the large output of the Golden Horseshoe, which averaged about 17,590 oz. per month in July, August and September (the average grade of the ore being 1.38 oz. per ton) call for remark. (7) In the outside districts, the Ida H. N. Laverton has lately come into notice as a producer, and the large reserves with which the Great Fingall is credited, and its low working costs, are matters for congratulation and comment.

The Ivanhoe in 1902, I believe, held the record for low working costs on the Kalgoorlie field, at £2 1s. 4.58d. per ton; and, when the present additions and alterations to the plant are in operation, it is expected that the total costs, inclusive of London management, will not exceed 35s., and with the present grade of ore a profit of £2 per ton should be realized. In this connection, as working costs become lower, it should appear good policy for some of the higher-grade mines to enlarge their plant and output, and correspondingly reduce the average grade of the ore treated.

Ore Treatment.—The new Merton furnaces have given great satisfaction at the Great Boulder, where I had an opportunity of seeing them in operation, and are being largely introduced at other mines. They seem to have solved the difficulty of roasting the Kalgoorlie tellurides properly at a cheap rate.

The system of agitating slimes at the Kalgoorlie mines and circulating the solution for vat-leaching is most interesting and novel, and great perfection has been reached in disposing of worthless tailings by means of Robins belt-conveyors and 'flying foxes,' as well as in the conveyance of ore in the mills by means of 'grasshopper' conveyors. The relative advantages of the Diehl and roasting processes are still a subject of discussion, and they run each other very close. The Great Boulder Perseverance and Great Boulder roasting treatment is estimated to have cost about 21s. in 1902-3, while the cost of the Diehl process at Lake View Consols was reduced this year to about 17s. 10d.; the figure at which, I believe, it now stands. But I am informed that the Great Boulder Proprietary has also brought down costs, and that they amounted to only 16s. 9d. in August last.

The extraction by both methods varies within the limits of 92 to 96 per cent; which is exceedingly good.

Great credit is due to the Chamber of Mines, which is under the presidency of Mr. Richard Hamilton, for the active part it has taken in urging improvements on the government and public bodies in many directions; by endeavoring to promote legislation, and by taking action on various questions of importance, including the Esperance Bay railway, the amendment of the mining law, railway rates, etc. The Chamber has also done much to encourage discussion on topics of interest to the industry, such as the relative efficiency of various types of condensers, uniform cost-keeping and gold records; all this has tended to improve the status of the industry, to reduce mining expenses for the benefit of the capitalist, and to promote the safety and welfare of the working miner.

In conclusion, I may add that one of the great events of the year has been the completion of the government "water scheme," and the delivery of a large supply of fresh water to the mines of Kalgoorlie. A complete geological map of the Kalgoorlie field has also been published by the Geological Survey of Western Australia, and the government has founded a State School of Mines at Kalgoorlie.

Political organization and the exigencies of reform demand that government, in whatever form it exists, should partake of a more or less partisan character; but I think the government of Western Australia is becoming more alive to the fact that legislation in the exclusive interest of any particular section of the community is always a mistake.

NEW CALEDONIA.

BY F. DANVERS POWER.

The bulk of the New Caledonian nickel properties are held by two companies, the International Nickel Company of New York, which, among others, has absorbed the Nickel Corporation of London, and La Société le Nickel of Paris. There is also a new Paris-London flotation under the name of the Consolidated Nickel Mines, which has taken up some much-inspected properties owned by the Société d'Exploitation at Koniambo, Katepai, Poya-Mueo, Bourail, etc. The intention of this concern is to treat the ore forthcoming from these mines at the works of the Smelting Company of Australia, Dapto, N. S. W., a contract to this effect having been made. In view of the fact that the market price of nickel is under the control of the first above-mentioned American and French companies, it remains to be seen how this new company will dispose of its products at a profit.

Gauged by the exports, the production of nickel ore has been going on at a reduced scale during the past year as compared with 1901 and 1902. This is largely due to the fact that the Americans rushed ore home during 1901 and 1902 in anticipation of a possible change in Canadian legislation, consequently they had a large stock to work off, and the French during the same period shipped large quantities of ore in order to replenish their reserves, on which they had largely drawn while previous high freights had prevailed.

The net profit of the Société le Nickel for 1901-1902 was 2,306,305 fr., as against 1,982,747 fr. for 1900-1901. This has enabled the company to pay a dividend of 25 fr. per share, as against 22.5 fr. for the previous year, and this in the face of the fact that the capital has been increased from 10,000,000 to 15,00,000 fr. by the issue of 20,000 new shares. The company is constructing an aërial plant which is prolonged into the sea, by means of which ships lying off shore can be loaded; in this way it is hoped to economize 23 barges and 200 men.

Owing to a temporary increase in the demand for cobalt, and the consequent increase in price, there was an over-production in the early part of the year, which soon had the effect of lowering prices, and bringing matters down to their usual condition again.

Chrome mining has been given a great lift by the way in which the mines at Tiepaghi, in the northwest of the island, have turned out. This property belongs to the Société le Chrome, but has been let on a royalty basis for a period of four years; the right to mine for the unexpired portion of this period, a little over three years, has recently been purchased by the tributers for the sum of $200,000, during which time they hope to raise 100,000 tons carrying an average of 55 per cent sesquioxide of chrome. The anticipation of large outputs of chrome from New Caledonia has had the effect of unsettling the market price of this metal both in America and Europe.

Different chrome interests in New Caledonia, located at Tiepaghi in the northwest and at Plum and Baie du Sud in the southwest, were formed into one company at Paris during the year, under the name of the Société le Chrome. This company has worked some of the properties controlled by it at Plum, principally the old Lucky Hit mine. Tramways have been laid down and other preliminary work carried out in order to get ready for transporting ore to the coast. So far as Plum is concerned, it is reported that there exist large deposits of rock chrome of a very hard nature, in which state it is not marketable, being below 50 per cent sesquioxide; therefore a concentration plant has been erected. As to the Baie du Sud properties, there is no reliable information as to quantities of ore available. A sudden stoppage to the operations of the above company was due to litigation in Paris, the object of which seems to be to liquidate the company just formed, which will retard production from that quarter for the time being.

M. Colomer, an engineer, was sent out by the French shareholders in the coal properties of the Noudoue basin to report on the seams. He put on a number of men for a time and did considerable work, but nothing further has been done since.

For want of the necessary funds, the railway line in course of construction from Noumea to Bourail has had to stop short at Dumbea, the first section.

SOUTH AFRICA.

BY W. FISCHER WILKINSON.

In reviewing the events of the year 1902, I was able to say that the gold mining industry had made steady progress toward regaining the important position that it held before the war, and although the maximum figures of 1898 have not yet been reached, a steady expansion can again be recorded. The value of the gold produced during 1903 was £12,589,248, as against £7,253,665, which was the value of the production during 1902. That a more rapid expansion has not taken place is due entirely to the scarcity of native labor.

The returns for 1903 are far below the producing capacity of the equipped mines, nearly all of which have some stamps standing idle, owing to the insufficient supply of labor. The position that the industry had reached in October, 1903, was equivalent roughly to 72 per cent of the results obtained in August, 1899, just before the war.

In July, 1903, the number of stamps erected was 7,145, of which 3,725 were running and 3,420 were idle. The earning capacity of the idle stamps, according to Mr. H. H. Webb, was £11,000,000, which would have given employment to 5,600 skilled white men, whose wages would have been £2,000,000 and dividends amounting to £3,000,000 would have been earned. These figures show the gravity of the labor problem in the Transvaal, about which so much has been said and written during the year.

The economic position of the Transvaal has been subject to very detailed scrutiny during 1903, and a large amount of statistical information has been collected, to summarize which in the space allotted to me is a formidable task. Among the most important reports published is the descriptive and statistical statement of the gold mining industry of the Transvaal, annexure to the Thirteenth Report of the Transvaal Chamber of Mines for the Year 1902, which was prepared by a committee of the leading engineers on the Rand for the use of Mr. Chamberlain on the occasion of his official visit, as Secretary of State for the Colonies, to South Africa in the early part of the year. This exhaustive report was accompanied by tables and maps, and is a mine of information concerning the position and prospects of the mining industry. An extract of some of the statistics will be given below.

It is shown that 120 companies had, on December 31, 1902, an issued capital of £53,075,330, with a market valuation of £173,126,414, and that 71 companies had erected 6,560 stamps. One hundred and eleven companies had incurred a capital expenditure, on development and equipment, of not less than £36,919,650, and 47 companies had paid dividends aggregating £19,-477,907, so that, apart from the cost or purchase of mining property, some £17,441,743 had been spent in excess of the amount received back in dividends. The average capital expenditure on development and equipment on 6,325 stamps has been £4,811 per stamp. The projected expenditure in connection with deep-level mines for the next ten years, is about £50,000,000.

Further statistics of interest prove that the cost of working during 1902 was estimated at 2s. 10d. per ton more than 1898, or 3s. 4d. including the present government tax on profits; that the population south of the Zambesi is, whites, 1,000,000; natives, 5,000,000; total, 6,000,000; and that the labor employed on the mines in 1899 was: Kaffirs, 100,000; whites, 12,000; the ratio of white labor to black being in 1898 as 1 to 7, and in 1902 as 1 to 5.

Another report of great interest to the gold mining community was that prepared by Mr. H. Ross Skinner on behalf of the Witwatersrand Native Labor Association on the subject of Asiatic labor, which was published in November. Mr. Skinner visited China and countries where the Chinese had been employed in mines and formed a favorable opinion as to their suitability for labor in the mines, and as to the possibility of obtaining a sufficient supply.

The government of the Transvaal made their own inquiry into the labor question and appointed a commission to investigate the subject. This commission has issued its report, and as the members of the commission were not unanimous, majority and minority reports were issued. The findings of the majority report were as follows:

"First, the demand for native labor for agriculture in the Transvaal is largely in excess of the present supply, and as the development of the country proceeds this demand will greatly increase.

"Secondly, the demand for native labor in the Transvaal for the mining industry is in excess of the present supply by about 129,000 laborers, and, while no complete data as to the future requirements of the whole industry are obtainable, it is estimated that the mines on the Witwatersrand alone will require within the next five years an additional supply of 196,000 laborers.

"Thirdly, the demand for native labor for other Transvaal industries, including railways, is greatly in excess of the present supply, and will increase concurrently with the advancement of mining and agriculture.

"Fourthly, there is no adequate supply of labor in central or southern Africa to meet the above requirements."

The commission states that the native labor requirements at present are as follows: For mining purposes, 129,364; for agriculture, 80,000; for railways, 40,000; total, 249,364. .

It is estimated that within five years the number required will be 650,574. The commission also states that the evidence of the past is overwhelmingly and conclusively against the contention that white labor can successfully compete with black in the lower fields of manual labor.

With reference to the minority report, the chief interest attaches to the support given to the opinion of Mr. Creswell, the late manager of the Village Main Reef mine, who has been a warm advocate of the employment of unskilled white labor, but whose experiments in this direction at the Village Main Reef mine have been adversely criticised by other engineers.

The question as to how far unskilled white labor could be economically employed on the Rand was very carefully gone into by the committee of engineers who signed the Chamberlain report already referred to, and it was estimated that, assuming a white unskilled laborer at 12s. per day equals in efficiency two kaffirs at 2s. 4d. per day with food each, the average cost of production would be increased 10s. 1d. per ton and the result would be that out of 79 mining companies, 48 would be losing concerns, 19 would barely clear expenses, and only 12 would give satisfactory returns. Under these conditions only the richest reefs would be workable, and the low-grade ores, which occur so abundantly and on which the permanent prosperity of the Transvaal depends, would remain undeveloped.

Although recruiting for native labor has been prosecuted with vigor during the past year, the results have been very disappointing. The number of natives employed on the mines at the end of January was 49,506, and this number was only increased to 68,958 by the end of October. This small increase only goes a very small way toward meeting the demands of the mines, and it is evident that to insure rapid progress Asiatics must be imported.

Although the labor question has occupied the largest share of public attention during the past year, a good deal of other useful work of benefit to the mining industry has been carried out. The water commission has been investigating the water supply of Johannesburg and of the mines. The health and well-being of the miners has been studied by two other commissions, namely, the Housing Commission and the Miners' Phthisis Commission, and much valuable information on these subjects has been obtained. The Transvaal government can be congratulated on having spared no effort to have every matter of public interest thoroughly ventilated before legislation.

Another important inquiry carried out during the year was that by Mr. Henry Birchenough, who went out to report on the present position and future prospects of British trade in South Africa. An interesting blue book of 160 pages was the result of his investigation. The report takes a very optimistic view of the future of the Transvaal and anticipates an enormous increase in the future in the trade between Great Britain and her colonies. Although foreign competition is very active, America and Germany being the most formidable competitors, no less than 75 to 80 per cent of the imports into South Africa come from Great Britain or from British possessions.

Turning now to the working of the mines, it is satisfactory to be able to record an increased efficiency in many directions. Particularly is this noticeable in the employment of native labor, influenced by the extension of the contract system and by the stricter administration of the liquor law.

A reduction has been made in many cases in the ante-bellum working costs, which is all the more satisfactory, taking into consideration the fact that the mines are not working at their maximum capacity or under the most favorable conditions.

One great drawback to the economical working of the mines has been the necessity, arising from the shortage of labor, of an excessive use of rock-drills which, when a narrow reef is being worked, break a larger amount of waste rock than is the case when the drilling is done by hand. A noticeable reduction in the cost of mining comes under the head of explosives: To take one example, at the Henry Nourse mine the expense of explosives per ton crushed, in 1899, was 3s. 5.5d., while in 1903 the cost was reduced to 2s. 8.3d., a reduction of 22 per cent. Reduced railway rates also account for a considerable saving in the coal bill. As regards native labor, the cost to this company in 1899 was 59s. 1d. per month, including wages, housing, food, etc., while in 1903 this figure was 74s. 3d., or an increase of 25.6 per cent. The native is now better cared for than he has ever been before.

The use of mechanical appliances has been extended wherever possible, especially on the surface, where belt-conveyors are now largely used in the transport of ore and tailings. Machines are also being introduced for emptying and filling cyanide vats.

A considerable amount of prospecting work has been done during the past year, more especially in the Heidelberg district, and the area over which mining can be carried on is being extended. The most important results obtained have been, however, on the western Rand, where systematic drilling with the object of picking up the Randfontein series has succeeded in securing information which, though not quite definite, goes a long way toward solving the problems as regards the extension of the main reef series in the western Transvaal, a matter which has long puzzled local geologists.

The dividends declared during the year amounted to £3,345,499. The following table shows the dividends that have been paid by gold mining companies since 1896:

Year.	Number of Companies.	Amount Paid.	Year.	Number of Companies.	Amount Paid.
1896	21	£1,530,381	1900	..	....
1897	25	2,707,180	1901	5	£415,813
1898	41	4,847,505	1902	23	2,148,715
1899	36	2,933,251	1903	29	3,345,499

These results, earned from a comparatively small part of the mining area, indicate the enormous possibilities of the Transvaal gold fields. Granted a plentiful supply of cheap labor, a rapid expansion of the gold mining industry may be confidently predicted. Without cheap labor mining must necessarily be confined to the richer ores, and the large quantities of low-grade ores will remain undeveloped. The situation has been so well summed up by Mr. H. H. Webb in his recent presidential address to the South African Association of Engineers that I will quote his words:

"If local conditions, such as transport, labor, living, etc., can be made to favor them, the future possibilities of these fields are very great, not only for the investor but for the working man himself and the community depending on the mining industry, which means, more or less, the whole of South Africa. The Witwatersrand is not a poor man's mining district. The mines as a whole are low-grade, requiring large capital for development and equipment, and their future expansion and success depends largely on capital and cheap unskilled labor to work the large bodies of low-grade ores and deep-level holdings yet untouched. Deprived of either capital or unskilled labor they cannot be attacked, and the future prosperity of the whole of South Africa will be affected, for, as we know, this country has not developed into an agricultural or manufacturing one, and the advancement of these depends directly on the prosperity of the mines."

Rhodesia.—The gold output of Rhodesia for the year 1903 was 231,872 bullion oz. of a value of £835,478. This output was obtained from 472,000 tons milled. These figures show a slight increase over the returns of 1902. The number of companies making returns was 11 in January and 18 in December. The mines giving the largest returns were the Selukwe, the Globe & Phœnix and the Wanderer, which three mines accounted for nearly one-half of the total value of the gold production of the country. The treatment of the ores is very similar to that practised on the Rand, namely, wet crushing in stamp batteries, amalgamating and cyaniding. One mine, the Wanderer, has a dry crushing mill with a capacity of from 50 to 80 stamps.

Considerable progress has been made in railway construction, and the country has now through railway communication between Beira and Cape Town. Branch railways from the main line have been constructed to some of the mining districts, while the line to the Victoria Falls from Bulawayo is not far short of completion. This policy of improving the means of communication will no doubt have a beneficial effect in the development of the mineral resources of this country.

DIVIDEND AND ASSESSMENT TABLES.

In the following pages there is given in tabular form the amount of the dividends paid and assessments levied by American mining and industrial companies, for a period of years ending with 1903. The names of many new companies appear this year, for the first time, in the list of dividend-payers. The figures are necessarily incomplete, since numerous companies do not make reports, and the facts cannot be obtained by inquiry. Many mines are operated by individuals, and by private firms, and if their profits could be included the total dividends shown would be materially increased.

DIVIDENDS PAID BY AMERICAN MINES AND INDUSTRIAL COMPANIES. $1=$1,000; Total, full amt.

Name of Company.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	Total Paid.
Aberdeen, c., N. M.						$32			$32,175
Acacia, g., Colo					$43			$14	57,560
Adams, s.l., Colo					88	15	$23		733,500
Ætna Con., q., Cal.	$40	$40	$40	$60	15				225,000
Ala. Con. Coal & I., pf., Ala				44	130	172	172	172	689,680
Ala. & Ga. Iron, pf.								7	6,500
Alamo, g., Utah.				3					2,500
Alaska Goldfields, Alaska				125		135		135	395,000
Alaska-Mexican, g., Alaska.	80	90	72	72	72			108	573,381
Alaska-Treadwell, g., Alaska	350	300	300	300	30	300	300	450	5,275,000
Allis-Chalmers, pf.						569	1,138	1,138	2,863,750
Alma Oil, Cal.								46	45,600
Alpha Oil, Cal.						1			1,250
Altoona Coal & Coke, Pa						75			75,000
Amalgamated, c., Mont				1,500	6,000	8,304	3,847	3,078	22,734,407
Amanda, g., Colo.					10				10,000
American, g.s.l., Colo		36	54	60					446,000
American Agric. Chem., pf.				510	1,020	1,025	1,028	1,088	4,670,760
American Cement, Pa.				60	80	160	160	160	540,000
American Coal, Md	120	120	135	150	255	150	150	150	1,432,500
American Fuel Oil, Cal.				3	12	1			16,000
Am. Iron & Steel, com					34	19	10		256,100
Am. Iron & Steel, pref.				50	150	150	150	150	650,000
Am, Sm. & Ref., pref.				1,13	1,545	2,709	3,500	3,500	12,391,553
Am. Steel Foundries, pf.							233	930	1,162,500
Am. Zinc-Lead Sm., Mo				120	60				180,000
Amistad y Concordia, Mex.						17	63	86	165,286
Anaconda, c., Mont.			3,000	3,900	4,800	3,900	1,200	1,200	23,250,000
Anchoria-Leland, g., Colo.	30	72	72	36					198,000
Anderson, g., Colo					15				15,000
Anglo-Mexican, g., Mexico.	271	90	180	180					1,825,048
Annie Laurie, g.s., Utah							60	225	285,000
Apollo Con., g., Alaska.		100		40	70				110,000
April Fool, g., Nev.				16					16,000
Argentum-Juniata, s., Colo				42					198,000
Argonaut, g., Cal			180	240	70				490,000
Arizona, c.s., Ariz			405	484	576	1,634	896	673	4,668,258
Arizona Western Oil, Cal					6				6,000
Associated, g., Colo			50	12					62,000
Atlantic, c., Mich.		40	40		80	80			940,000
Aztec Oil, Cal.						12	16	14	43,950
Bald Butte, g., Mont.	38	83	98	150	38	180	160	15	1,312,148
Bartolome de Medina, Mex							20	17	79,728
Barreno, g.s., Mex								14	67,954
Big Four. g., Colo					15				15,000
Big Six, g.s.l., Colo								3	17,500
Blue Bird Extension, Utah						1			834
Bon Air, Coal & Iron, Tenn., pf.							24	133	136,937
Bonanza Dev., g., N. Mex				1,050					1,050,000
Boston, q., Cal				20					20,000
Boston & Colo., Sm., Colo.				56	34	45	95		402,350
Boston & Montana, c. s., Mont.	1,500	1,800	1,950	5,375	6,450	5,250	400	1,200	28,325,000
Boston-Aurora, z., Mo., pref.				29	37				66,160
Boston-California, g., Cal				72					72,000
Boston Gold-Cop. Sm., Colo.					50	100			150,000
Boston-Little Circle, z., Mo.				75	13	25			112,500

DIVIDENDS PAID BY AMERICAN MINES AND INDUSTRIAL COMPANIES.—*Continued.*

Name of Company.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	Total Paid.
Boston-S. Dak., g., S. Dak					$10				$10,000
Bosun, s.l., B. C.						$13			12,500
Breece, i.s., Colo			$10	$40	30	70	$20	$10	200,000
Buckhorn Oil, Cal					4	4			7,200
Buena Vista, g.s., Mex								5	5,000
Buffalo Hump, g., Idaho					275	25			300,000
Bull Hill, Con., g., Colo.					15	38			52,500
Bull'n-Beck & Cham., g.s., Utah	$290	$170	90	120	60				1,498,400
Bunker Hill & Sull., s.l., Idaho		102	228	201	252	252	138	96	1,520,000
Burlington Oil, Cal					3				3,600
Butler-Liberal, g.s., Utah.								3	2,500
Butler's Salvador, g., C. A.								252	252,000
Butte & Boston, c.s.l., Mont					1,000	600			1,600,000
Butterfly-Terrible, g., Colo.						31			31,250
California, g., Cal.						43			43,200
Calumet & Arizona, c., Ariz.								400	400,000
Calumet & Hecla, c., Mich.	2,500	5,000	5,000	10,000	7,000	4,500	2,500	3,500	83,350,000
Cambria Iron, Pa.				339	339	339		339	1,693,265
Cambria Steel, Pa				660	940	2,150	1,350	1,350	6,450,000
Camp Bird, g., Colo.							125	843	967,704
Cariboo-McKinney, g., B. C	76	48	67	72	86		19		496,387
Carisa, g.s.c., Utah						30			30,000
Carmen (Hidalgo) Mex.								9	78,616
Carmen-Guanajuato, Mex								18	17,750
Cashier, g.s., Colo								18	17,820
Center Creek, l.z., Mo				10	30	30	20	20	110,000
Center Star, g., B. C.					35	175			210,000
Central, l., Mo		28	54	60	65	60	60	60	385,000
Central C. & Coke, com., Mo.							86	308	551,250
Central C. & Coke, pf., Mo							84	94	796,872
Central Eureka, Cal.						16	8	96	235,995
Central-Eureka, s.g.l., Utah.	390	98	15	120	268	200	50		2,667,708
Central Oil, Cal					73	25	25	30	152,500
Central Oil, W. Va.					23	63	75		142,500
Central Point Con., Oil, Cal					4	38			45,600
Century, g.s.l., Utah								9	9,000
Champion, g., Cal		51	26	35					321,700
Champion, c., Mich.								100	100,000
C. K. & N., g.s., Colo							14	57	71,595
Cherry Hill, g., Cal						23	30		62,500
Chicago Oil, Cal.							10		10,000
Chippewa Con., g.s.l., Colo							3		2,500
Cinco Sonores, Mex						9	57	57	711,935
Clinton, g. s., Colo.								36	60,000
Colo. City Mg. & Leas., Colo.							65		65,000
Colorado Fuel & Iron, Colo. com.						682	805		1,642,500
Colo. Fuel & Iron, Colo., pref	160	80			800	160	160	80	1,560,000
Columbia, l., Mo					12				12,125
Columbus & Hocking C. & I., O.								52	86,531
Commodore, g., Colo.		20	20	48					432,000
Con. Mercur, g., Utah	200	250	355	100	225				1,591,000
Con. Mercur, g., (new), Utah.					110	375	395	150	1,030,000
Consolidated, g., Colo.				10	110	182	76		378,000
Consolidation Coal, Md	205	205	205	205	205	205	205	205	6,536,650
Continental, z., Mo							18	35	52,800
Continental Oil, Cal.						10			10,400
Copiapo, c., Chile						168		40	2,865,900
Cripple Creek, g., pf., Colo							5		45,000
Cripple Creek Con., g., Colo					160				160,000
Crœsus, g., Cal			29	19	103	76			227,300
Crowned King, g.s.l., Ariz.			96	121					242,760
Crow's Nest Pass Coal, U. S.						245	250	304	796,423
Crucible Steel, pref., U. S					427	1,740	2,187	1,312	5,250,000
Cummings Cement, N. Y	27	27	27	27	27	27	27	27	216,000
Dabney Oil, Cal						10	120	16	145,000
Dalton & Lark., g.s.l., Utah						263			350,000
Daly-West, s.l.g.c., Utah				120	487	600	1,004	1,332	3,491,000
Deadwood-Standard, g.pref. S.D								6	6,000
Deer Trail Con., g., Wash				55					55,000
De Lamar, s.g., Idaho.	500		48	48	48	192	122	32	2,740,340
Denver & Cripple C'k, g., Colo					11				10 625
Dewey Con., Utah.					2	3			5,850
Diamond Star Oil, Cal.					6				6,000
Dixie, g., Nev.					10	158			167,500
Doctor Jack-Pot, g., Colo						232			232,000
Doe Run, l., Mo		30	30	60	60	60	60	90	627,072
Dolores, s.g., Mex								25	25,000
Dominion Coal, N. S						240	120	1,290	3,090,000
Dominion I. & St., pf., N. S						175	350		525,000

DIVIDENDS PAID BY AMERICAN MINES AND INDUSTRIAL COMPANIES.—*Continued.*

Name of Company.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	Total Paid.
Dos Estrellas, g.s., Mex.								$359	$582,825
East Notaway, g.s., Colo								20	20,000
Eldorado, g., Cal				$10					10,000
Elkton Con., g., Colo.	$90	$260	$220	68	$259	$325	$100		1,404,461
El Oro, g.s., Mex						946	564	1,004	2,514,400
El Paso, g., Colo.						24		61	152,250
Empire State, g.s.l., Idaho			67	256	355	586	304	227	1,738,604
Empire Steel & Iron, pref.				71	107	71	75	75	373,350
Esperanza, s.g., Mex						171	159	84	1,154,199
Eureka, g., Cal.						10			10,000
Eureka Oil, Cal						2			2,000
Fanny Rawlings, g., Colo				20					20,000
Favorite, g., Colo.					48				48,000
Feather River Expl., g., Cal.						20			20,000
Federal Mg. & Sm. pf., Idaho								184	183,750
Figaro, g., Colo						10			10,000
Finance Con., g., Colo							2		2,000
Florence, s., Mont	54	54	44	44	20				223,780
Four Metals, Colo						25			25,000
Four Oil, Cal.						8	19	27	56,362
Fraternal, s., Mex								22	51,263
Free Coinage, g., Colo						140	20	10	170,000
Frontino & Bolivia, c., Colom						103			1,211,703
Fullerton Oil, Cal.						1			750
Garfield, Con. g., Colo				34		125			159,000
Gemini, g., Utah					50		150	200	1,050,000
General Chem., com				129	285	287	296	371	1,300,537
General Chem., pref				396	494	506	565	600	2,575,178
George's Creek Coal & I., pf., Md								33	33,000
Gold Belt Con., g., Colo.					113				112,500
Gold Coin of Victor, Colo		120	120	210	240	360	260	10	1,230,000
Gold Deposit, g., Colo					10				112,500
Gold Hill Bonanza, Colo.							15		15,000
Gold King, g., Colo	11	25		66	112	56		47	459,056
Golden Cycle, g., Colo		60	60	105	120	30			408,560
Golden Cycle (new), g., Colo							56	247	303,750
Golden Eagle, g., Colo.	10			10	5	10			98,916
Golden M. & Ext., g., Ont.				10					10,000
Golden Star, g., Ont				46					45,500
Goodenough, s.l., B. C.							7		13,188
Grafton, g., Colo				10					10,000
Granby Con., B. C.								134	133,630
Grand Central, g.s., Mex.					120				840,000
Grand Central, g., Utah			219	348	25			225	916,250
Grand Gulch, c., Ariz					10				9,600
Grant Oil, Cal.								5	5,000
Grass Valley Expl., g., Cal				23	7				30,000
Gray Eagle Oil, Cal					50	97			217,000
Greater Gold Belt, g., Colo.					76				76,000
Great Western Oil, Cal					10				10,000
Green Mountain Oil, Cal.						5			5,000
Greene Con., Mex.						220		432	651,820
Guadalupe Mill, Mex.						157	123	31	3,515,750
Guggenheim Explor., Mex								551	551,250
Gunnell, g., Colo								30	30,000
Gwin, g., Cal.			16	35	35	66	120	165	436,500
Hanford Oil, Cal						6	7		13,000
Hecla, l.s., Idaho					100			20	120,000
Hecla Con., s.l., Mont	45	30		15	50	30			2,250,000
Helena, g., Oregon.					45	72			116,500
Helena & Liv., S. & R., Mont.					90				90,000
Heywood Oil, Tex					32			16	144,000
Hidden Treasure, g., Cal.					29				457,452
Higgins Oil, Tex.							97		96,850
Holy Terror, g., So. Dak.		36	81	50	5				172,000
Home, g., Colo					100	137			237,500
Home Oil, Cal.					200	61	90	43	492,500
Homestake, g., So. Dak	375	375	636	963	1,260	1,260	1,058	655	12,367,750
Homestake Oil, Cal					23	12	1		33,000
Horn Silver, g.s.l.z.c., Utah	50		80	20	20	72		20	5,362,000
Houston Oil, pf., Tex						224	448	224	896,500
Idaho, g., B. C				28					292,000
Idaho, g., Idaho.					8				8,188
Imperial Oil, Cal						20	24	240	500,000
Independence Con., g., Colo.					100	181			281,375
Ingham Con., g., Colo						34			33,981
Int'l Ach. Graph., pf., N. Y						35	35	35	105,000
International Nickel, pf								350	349,660
Iowa, g.s.l., Colo	50	25	10		39	67	67	67	336,837

DIVIDENDS PAID BY AMERICAN MINES AND INDUSTRIAL COMPANIES.—*Continued.*

Name of Company.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	Total Paid.
Iron Silver, s.l., Colo					$50			$200	$2,850,000
Isabella, g., Colo	$180	$68		$270	158	$23			742,500
Jackson, g., Cal					6				6,000
Jamison, g., Cal				12		12		47	120,000
Jeff. & Clearf. Coal, Pa., com					30	30	$75	75	180,000
Jeff. & Clearf. Coal, Pa., pref			$75	75	75	75	75	75	600.500
Kansas-Burroughs, g., Colo								60	60,000
Katinka, g., Colo						10			10,000
Kemp-Calhoun, g., Colo								5	5,000
Kend. & Gelder Sm., Colo						20			20,000
Kendall, g., Mont								230	.305,000
Kennedy, g., Cal						10			1,801,000
Kern Oil, Cal					375	25	20		370,000
Kern River Oil, Cal					10				10,000
La Fortuna, g., Ariz		188	238	238	238	150	100		1,166,000
Lake City, g., Colo					4				3,875
Last Chance, g., B. C.			20	25					45,000
Last Dollar, g., Colo				30	90	60		30	210,000
Lawrence, g., Colo					10				10,000
Lehigh Coal & Nav., Pa	574	574	574	574	789	861	717	946	21,041,449
Le Clair, g., Colo								18	17,500
Le Roi, g., B. C.				240					1,305,000
Le Roi No. 2, g., B. C.						144	144		288,000
Liberty Bell, g.s., Colo							13	78	91,233
Lightner, g., Cal.					15	15	15	15	186,615
Lillie, g., Colo.			50	136	45				349,183
Los Angeles Oil & Trans., Cal.						3			2,500
Madison, g., Colo					35				35,000
Magnolia, g., Colo					187		11		198,000
Mammoth, g.s.c., Utah	100		200	260	200	100			1,840,000
Marion Con., g., Colo.				5					300,000
Mary McKinney, g., Colo				30	150	150	120	90	560,000
Maryland Coal, Md., pref	94	75	85	94	94	104	141	160	1,046,135
May Day, Utah						18	12		30,000
Mesquital, Mex						36		15	51,458
Midget, g., Colo					25	15	30		195,000
Milwaukee, g., Ida.								20	20,000
Mine La Motte, l., Mo								240	240,000
Mines Co. of Am.								465	465,000
Missouri Zinc Fields, Mo., pref				21	11				31,885
Modoc, g., Colo		10	90	45	60	35	25	20	270,000
Monarch, g., Colo.					120				120,000
Monongahela R. C. & C., Pa.pref					694	694	694	694	2,777,320
Montana Coal & Coke, Mont					120				120,000
Montana, g.s., Mont			36	99					453,700
Montana Ore Purchas., Mont.	320	160	160	560	240	722	324	648	3,294,000
Montana-Tonopah, g.s., Nev								43	42,750
Monument, g., Colo.			13	6		3			21,124
Morning Star, g., Cal			82	63	7				854,400
Morse, g., Colo				15					215,650
Mountain, c., Cal		31	62	1,080	1,200	720	540	143	3,776,250
Mount Diablo, s., Nev.					5				260,271
Mount Rosa, g., Colo.	5	10	20	40					75,000
Mount Shasta, g., Cal				6					6,000
Napa Con., q., Cal	70	80	80	110	40	40	40	40	1,220,000
National Carbon, pf						315	315	315	1,575,000
National Lead, com.			149	149	149		298		1,341,486
National Lead, pref.	1,043	1,043	1,043	1,043	1,043	1,043	1,043	1,043	13,972,163
Natividad, s.g., Mex						24	48	109	272,463
Nevada-Keystone, g.s., Nev							9	33	42,624
New Central Coal, Md.			20	40	40			20	250,000
New Idria, q., Cal		10	70	110	60	70	80	120	520,000
New Jersey Zinc		600	600	600	1,000	400	1,600	1,200	6,000,000
New Leadville Home, g., Colo					100	137	25		265.520
N.Y. & Hond. Rosario,s.g.,C.A.		165	165	180	255	240	100	15	1,785,000
New Zealand Con., g., Colo.						46	32		76,950
North Star, g., B. C.					39		78		117,000
North Star, g., Cal.				50			47	125	706,356
Nova Scotia Steel & Coal, com.							268	247	515,000
Nova Scotia Steel & Coal, pref.						42	82	82	206,000
Nugget, g., Colo.						30			84,730
Ohio & Ind. Nat. Gas, U. S.					760	360	360	360	1,440,000
Oil City Petroleum, Cal.						15			15,000
Old Colony, Z. & Sm., Mo.					68	70			138,184
Olive, g., Ont				12					12,000
Omega, g., Colo					18				18,188
Ontario, g., Colo								7	7,500
Ontario, s., Utah	180	230		15	90	90	180		14,917,000
Original Empire, g., Cal				100					530,000

DIVIDENDS PAID BY AMERICAN MINES AND INDUSTRIAL COMPANIES.—*Continued.*

Name of Company.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	Total Paid.
Osceola, c., Mich	$125	$191	$277	$558	$558	$575			$4,245,800
Pacific Coast Borax, Cal				100	240	228	$228	$228	1,535,500
Park Oil, Cal					5				4,897
Parrot, c.s., Mont			483	1,242	1,034	1,264	115		5,775,925
Payne, g., B. C.				50		78			1,438,000
Peerless Oil, Cal.							47	144	190,400
Pennsylvania Coal, Pa	1,500	800	800	800	800	2,160			21,860,000
Pennsylvania Con., g., Cal			28	68	26			25	187,075
Penn. Salt Mfg., Pa			150	150	300	300	300	300	13,450,000
Pennsylvania Steel (of N. J.), Pa						1,151	1,177	1,177	3,505,750
Penoles, s.l., Mex.						693	1,128	510	2,488,114
Petro, s., Utah				15					32,000
Petroleum Dev., Cal							25		25,000
Phila. Nat. Gas, com., Pa						848	905	926	3,416,831
Phila. Nat. Gas, pref					200	200	400	200	1,009,067
Pinto, g., Colo								10	10,000
Pioneer, g., Cal.			50	13					62,500
Pioneer of Nome, Alaska							300		300,000
Pittsburg Coal, Pa.					2,240	2,079	2,240	2,079	8,316,336
Pittsburg Oil, Cal								48	48,000
Plumas-Eureka, g., Cal.	25	25			84	34			2,831,294
Pocahontas Coal, pf., Pa.								90	90,000
Pointer, g., Colo.						25			25,000
Portland, g., Colo	240	330	570	720	750	720	270	360	4,657,080
Potomac Oil, Cal							3		3,178
Practical, g., Colo								30	30,000
Pride of the West, g., Ariz							15		15,000
Producers & Cons. Oil, Cal					53	4			56,500
Providence, g., B. C.								2	2,224
Providence, g., Colo						5			5,000
Providencia, Mex						16	60	9	169,740
Queen Bess Proprietary, g., B. C				25					25,000
Quicksilver, q., Cal., pf				22	22	22	21	22	1,931,411
Quincy, c., Mich.	1,000	800	650	950	900	900	700	550	14,120,000
Rambler-Cariboo Con., g., B. C				31	34	25	138		220,000
Raven, g., Colo			20	50	50	25			130,000
Real del Monte, g.s., Mex								54	2,926,884
Reco, s.l., B. C					10				287,500
Red Bird, g.s.l.c., Mont.								36	36,000
Reed Oil, Cal						50	50	400	500,000
Republic Con., g., Wash			120	158	105				382,500
Republic I. & St., pref.				355	1,423	1,423	1,423	1,429	6,053,476
Reward, g., Cal				20					20,000
Richmond, g.s.l., Nev					13				4,453,797
Rob Roy, z., Mo.							1	2	2,253
Rocco-Homestake, s.g.l., Nev						9	45	22	90,000
Rocky Gulch, g. Ore					25		2		90,000
Sacramento, g.s.l., Utah	15	15	60	50		15		60	193,000
Saint Joseph, l., Mo		144	150	150	150	150	150	225	3,834,500
San Carlos, Mex						212	22		234,329
San Diego de Char., Mex.						32			61,100
San Francisco Mill, Mex						37	61		287,160
San Joaquin Oil, Cal						25	35	25	185,000
San Rafael, Mex						136	54	201	1,975,220
Santa Rita, g., Colo.					4				4,000
Senator Oil, Cal						5		4	9,045
Shawmut Oil, W. Va.						100	50	53	203,000
Shelby Iron, Ala				130	120		160	150	840,000
Silver Hill, g.s., Nev							5	18	28,800
Silver King, g.s.l., Utah	375	450	450	625	1,000	1,300	1,300	1,300	7,350,000
Silver Shield, g.s.l., Utah					2	3			4,500
Sloss-Sheff, Steel & Iron, pref					332	456	469	469	1,736,000
Small Hopes, s., Colo.			25	25					3,325,000
Smuggler, s.l.z., Colo.	110		120	275	360	360	20		2,175,000
Soledad, Mex							25	42	264,712
Sorpressa, Mex.						27		14	200,062
Southern Boy, g., Colo					18				17,500
Southern Cal. Oil & Fuel, Cal.					3	33			39,000
South Godiva, g.s., Utah						2			2.000
South Swansea, g.s.l., Utah	20	50	38	53		8			167,500
South Winnie, g.s., Colo						15			15,000
Spearfish, pf., So. Dak							18	80	97,020
Specie Payment, Colo.							40	25	65,190
Specimen, g., Colo					153				153,347
Squaw Mountain, g., Colo.				10					10,000
Sta. Gertrudis, Mex.						81	88	132	2,780,448
Sta. Maria de Guad, Mex						133	85		377,918
Sta. Maria de la Paz, Mex.							104	114	1,962,373
Standard, c., Ariz							40		40,000

DIVIDENDS PAID BY AMERICAN MINES AND INDUSTRIAL COMPANIES.—*Concluded.*

Name of Company.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	Total Paid.
Standard, s.l., Idaho					$320	$300	$150	$225	$2,945,000
Standard Con., g., Cal.		$40	$27	$60	71	71	71	71	4,178,170
Standard Oil of N. J.				26,325	47,800	46,660	43,650	42,680	206,715,000
St. Eugene Con., s., B. C.				2		210			210,000
St. John del Rey, g., Brazil						102	142	153	14,158,949
Stratton's Independence, g. Colo				976	1,789	788	240	375	4,130,860
Strong, g., Colo		250	300	300	300	300	375	300	2,575,000
Sunday Creek, coal, Ohio								5	15,750
Sunday Lake Iron, Mich.						40			40,000
Sunset, s.l., B. C.							6		6,000
Susquehanna I. & St., Pa				180	113	68	90	90	762,500
Swansea, s.l., Utah	$20	50	65	65	75	29			330,500
Syndicate, g,. Cal.							2		82,000
Tamarack, c., Mich	300	360	440	600	1,200	1,200			8,490,000
Temonj, g., Colo					250				250.000
Temple Iron, Pa.							7	14	21,500
Tenn. C., I. & R.R., com.					451				1,102,144
Tenn. C., I. & R.R., pref.					139	20	20	20	307,104
Tennessee, c., Tenn								219	218,750
Texas & Pacific Coal, Texas				140	120				1,860,000
Thirty-three Oil, Cal							120	120	240,000
Thomas Iron, Pa								200	200,000
Tidewater Steel, Pa., pref.								30	30,000
Tomboy, g., Colo	300		50	152	144	216	72		1,244,000
Tonopah-Nevada, g.s., Nev								70	70,000
Torreon Metallurgical Co., Mo								270	269,500
Touraine, g., Colo					88	9			96,119
Town Topics, g.c., Colo.						15	20	15	50,000
Trimountain, c., Mich.								300	300,000
Trinity County, g., Colo.								35	34,561
Uncle Sam Con., g.s., Utah.						45			45,000
Union, g., Colo.	13	23			313	25	25		445,244
Union, z.l., Kas					9	7			16,000
Union Mill, Mex.						31	26	35	413,423
Union Oil, Cal						272	215	113	815,942
United, c., pf., Mont							150	300	450,000
United, g., Colo							280	40	319,933
United (Creede), g., Colo								10	45,000
United, z.l., Mo				3	28	30	47	50	156,081
United Petroleum, Cal							34	17	50,638
United States Crude Oil, Cal					3	24			27,220
U. S. Crude Oil, Cal					3	24			27,220
U. S. Marble, Wash						20			20,000
U. S. Red. & Ref., com							177	237	414,078
U. S. Red. & Ref., pf.							236	237	472,821
U. S. Steel Corp., com						15,228	20,333	12,708	48,267,952
U. S. Steel Corp., pf.						26,753	35,720	30,404	92,876,993
United Verde, c., Ariz.				3,000	4,499			2,025	15,060,322
Utah, g., Utah	22	4		2	2	14	12	14	221,000
Utah Con., c., Utah.						732		954	1,686,000
Ventura Con. Oil, Cal							5		5,000
Vic. C. & Coke, com., W. Va.						15			15,000
Vic. C. & Coke, pf., W. Va						9	6		15,000
Vindicator, g., Colo.			138	178	189	170	253	198	1,115,000
Virginia-Car. Chem., com	10	40	40	270	360	480	1,329	700	3,678,829
Virginia-Car. Chem., pref				800	800	920	960	960	7,020,869
Waldorf, g., Colo							24	23	47,000
War Eagle, g., B. C			177	315	53				540,250
Warner Oil, Cal						10			10,000
Warwick Iron & Steel, Pa.				64	132	84			279,324
Wasp No. 2, g., So. Dak						3	9		218,410
Weatherly-Bonanza, g., Wash.				2					2,000
West Lake Oil, Cal					50				50,000
West Mountain, g.s., Utah.								9	9,000
West Shore Oil, Cal						20	45	60	105,000
Westmoreland Coal.				750	750	750	750	750	8,250,000
White Rock, g., Nev							2		2,000
Whittier Con. Oil, Cal.					6				5,600
Wolverine, c., Mich.			60	210	240	240	240	330	1,320,000
Wythe, l.z., Va					76				76,000
Yankee Con., g.s.l., Utah							75		75,000
Yellow Aster, g., Cal		40	131	145	150		30	80	553,780
Ymir, g., B. C.				30		192	48		288,000
Yreka, g., Cal.					50	8			58,000
Yukon Oil, Cal.				3	18				21,000
Zoe, g., Colo					8				7,500

c., copper; g., gold; i., iron; l., lead; q., quicksilver; s., silver; z., zinc.

ASSESSMENTS LEVIED BY MINING COMPANIES.

Name of Company.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	Total Levied.
Acacia Oil, Cal						$6,000			$6,000
Acme Oil, Cal.						10,000			10,000
Acorn, g.s.l., Utah.				$365	$760				1,125
Addie, g.s.l., Utah							$2,500		5,000
Admiral, g., Utah							2,500		2,500
Ætna, g.s.l., Idaho					5,000				5,000
Ætna, g.s.l., Utah			$2,500	500					3,000
Ætna Oil, Cal.						50,000			50,000
Ajax, g.s.l., Utah.						15,000	30,000	$15,000	60,000
Alaska, g., Cal						20,000			20,000
Alaska, g.s.l., Utah				34,000	20,000	12,000	28,000	24,000	118,000
Albion, g., Utah.						20,000	24,000	8,000	52,500
Alexandria, g.s.l., S. Dak				500	500				1,000
Alhambra, s., Nev			100,000						100,000
Allah, g., Utah.							2,500	2,500	5,000
Alliance Explor. & Mg., g., Cal.					5,000	2,000			7,000
Alliance, g., Utah.				15,000	10,000				225,000
Allison Ranch-Ford, g., Cal				5,000	10,000				15,000
Allouez, c., Mich			80,000			240,000			1,760,930
Alma, g., Cal							10,000	15,000	25,000
Alpha, s., Nev	$15,750	$8,400	8,400	3,150	3,150	3,150	6,300	5,250	337,050
Alta, s., Nev.	32,400	16,200	16,200	16,200	16,200	10,800	10,800	5,400	3,724,310
Alta, g., Utah.				938					938
Amelia, g., Cal					2,500				2,500
American, g., Cal.								50,000	50,000
Am. Oil & Ref., Cal					5,000	10,000			15,000
American, g.s.l., Utah.							2,000		18,000
American Mines, Utah							5,000	15,000	20,000
Andes, s., Nev	15,000	20,000	10,000	15,000	15,000	10,000	15,000	20,000	1,270,000
Annandale, g., Utah							5,000	6,333	11,333
Annie, g.s., Utah					5,000				5,000
Apex, c., Utah							5,000		5,000
Apollo, Alaska						10,000			10,000
App Con., g., Cal							50,000		50,000
April Fool, g.s.l., Nev							50,000		50,000
Argentum-Juniata, g., Colo							104,000		104,000
Argonaut Oil, Cal.					12,000	12,000			24,000
Arrastraville, g., Cal			20,000	20,000	10,000				50,000
Aurora, g.s.l., Utah							500		500
Bachelor's Oil, Cal.						6,000			6,000
Badger, g., Oregon					10,000	10,000		10,000	40,000
Badger Hill & Cherokee, g., Cal				60,000					60,000
Baker Divide, g., Cal.							12,000		12,000
Bald Eagle Oil, Cal								15,000	15,000
Baliol, g., Cal		25,000	30,000						55,000
Bank of Enoland, g.s.l., Utah								2,500	2,500
Bay City Oil, Cal						5,000			5,000
Bear Flag Oil, Cal						6,761			6,761
Belcher, s., Nev	50,200	57,000	20,800	36,400	52,000	52,000	26,000	10,400	3,691,600
Belle, g., Cal.					2,000				2,000
Bellefontaine, g.s., Cal			10,000	10,000	10,000	10,000		6,000	46,000
Ben Butler, g.s., Utah.				11,250	6,250	2,500	10,000	1,250	31,250
Ben Butler, No. 3, Utah								1,000	1,000
Ben Franklin, g., Cal.							15,000		15,000
Benton Con., g.s., Nev					20,000				20,000
Berkeley Crude Oil, Cal.							4,500		4,500
Best & Belcher, s., Nev.	25,200	75,600	30,240	40,320	60,480	30,240	50,400	55,440	2,827,963
Big Chief Oil, Cal.						5,000			5,000
Biesinger & Beck, s.l.g., Utah					756				756
Bingham Placer, g., Utah.				27,500	27,500		27,500		82,500
Black Bess, g.s.l., Utah.								15,000	15,000
Blue Bird, g., Utah				500					500
Blue Eagle, g., Utah						10,000	5,000		15,000
Blue Extension, g., Utah						5,500	2,500		7,500
Blue Goose, Cal						10,000			10,000
Blue Gravel, g., Cal					10,000				10,000
Bonanza Con., g.s.l., Utah								2,000	2,000
Bogan, s., Utah						12,500			39,375
Boss Tweed, g., Utah							10,000		18,000
Boston & Cripple C'k, g., Colo			20,000						20,000
Boulder, g., Cal			10,000	3,000	3,000	3,000			19,000
Bountiful, g.s., Utah.					5,000		15,000		20,000
Brown, g., Utah.							5,000		5,000
Brunswick Con., g.s., Cal	15,000	30,000		15,000	50,000	40,000	45,000	60,000	370,000
Buchanan, g., Cal			25,000						25,000
Buckeye, g., Utah	3,750	6,250	6,250						16,250
Buckhorn, g., Utah						1,000			1,000
Buffalo Hump Dev., g., Wash					200				200
Bullion, s., Nev	20,000	20,000	15,000	10,000	5,000	6,000	3,000	8,000	3,152,000
Bunker Hill, g.s., Utah				5,000	6,250				11,250
Burton, g.s.l., Utah.								1,000	1,000
Butler, g., Utah						3,000			3,000
Butte Basin, g., Cal.						2,500			2,500
Cactus Oil, Cal								2,000	2,000
Cadmus, g., Cal					10,000		8,000	4,000	22,000

ASSESSMENTS LEVIED BY MINING COMPANIES.—*Continued.*

Name of Company.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	Total Levied.
Caledonia, s., Nev	$5,000				$30,000	$15,000	$30,000	$60,000	$3,375,000
California, g., Cal.		$1,000		$2,000		2,000	4,500		26,000
California, g.s.l., Utah.							30,000	45,000	75,000
California Borax, Cal.					9,500				13,000
California Dredging, Cal.						30,000			30,000
California Mutual Oil, Cal.						12,500			12,500
California Oil, Cal						20,000			20,000
Canadian King, Wash.						1,000			1,000
Canton Placer, g., Cal							6,000	3,600	34,600
Carb. & Rattler, g.s.l., Utah.							24,000		24,000
Carbon Oil, Cal.									8,000
Caribou Oil, Cal					8,000	16,000			24,000
Carisa, g.s.l., Utah.								30,000	30,000
Carmelita Oil, Cal						10,000	10,000		50,000
Cassa Oil, Cal						2,000			2,000
Cedar Creek, g., Cal.			$2,000						2,000
Centennial, c., Mich.		120,000	300,000		270,000	180,000			910,000
Central Eureka, g., Cal		20,000			12,000				32,000
Central Mammoth, g., Utah.					500				500
Century, g., Utah.							10,000	10,000	20,000
Century Oil, Cal.						8,600	5,500		22,200
Cerulean, g., Cal.						5,000			5,000
Challenge Con., s., Nev.	7,500	50,000	1,000	12,500	22,500	5,000	5,000	10,000	484,500
Champion, g., Cal							17,000	32,300	139,803
Channel Bend, g., Cal			2,000						2,000
Chicago, g.s.l., Utah							2,500	1,250	3,750
Chicago & Mercur, g.s., Utah				1,000		1,000			2,000
Chloride Queen, Idaho						1,000			1,000
Chollar, s., Nev	28,000	44,800	50,400	28,000	39,200	22,400	22,400	39,200	2,198,800
Christmas, g.s., Utah.				1,500	3,000	1,500	1,500	1,500	9,000
Church, g., Cal			3,000						3,000
Cinnabar King, g., Cal.			1,000						1,000
Clarissa, g.s., Utah.				5,000	5,000				10,000
Cleveland, g., Utah			2,000	1,000					3,000
Clyde Oil, Cal.						5,000			5,000
Coe, g., Cal							25,000	8,000	33,000
Columbia, g.s., Utah			750						750
Columbus Con., g.s., Cal					2,000		3,000	4,500	9,500
Commonwealth, g., Utah							2,500		2,500
Comstock, g.s.l., Utah.						20,000	30,000		50,000
Confidence, s., Nev	7,488	14,976	13,728	8,736	9,984	99,984		9,984	583,806
Conglomerate, g.s., Utah					6,250				6,250
Con. Cal. & Va., s., Nev.	118,800	108,000	108,000	108,000	97,200		54,000	162,000	1,099,200
Con. Gold G. & Sulp., Cal							45,000		45,000
Con. Golden Trout, g., Cal							25,000		25,000
Con. Imperial, s., Nev.	500	10,000	10,000	10,000	20,000	10,000	10,000		2,250,000
Con. New York, s., Nev.	5,000	60,000	30,000	3,000				25,000	188,500
Con. St. Gothard, g., Cal.			35,000	15,000		10,000		5,000	75,000
Constellation, g., Utah					2,250	2,250			63,000
Contra Costa Coal, Cal						30,000			30,000
Contra Costa Oil, Cal.						5,000			5,000
Copper Queen, Utah							4,000		4,000
Copper Range, g.s.l., Utah								2,500	2,500
Corona Oil, Cal.						6,000			6,000
Crown Point, s., Nev.	70,000		25,000	20,000	15,000	15,000	20,000	20,000	3,060,000
Crusader Con., g.s.l., Utah					5,000		2,500		7,500
Dalton, g.s.l., Utah	5,000	2,500	7,500	5,000		5,000	7,500		71,250
Daylight, g., Utah.						10,000	8,000	10,000	28,000
Del Monte Oil, Cal.						20,000			20,000
Devil's Den Oil, Cal.						2,000			2,000
Dewey Gravel, g.s.l., Cal.					10,000				10,000
Dexter Tuscarora, g.s., Nev			30,000					8,000	46,000
Diamond Con., g.s.l., Utah.				8,000		8,000		4,000	20,000
Diamond Creek, g., Cal.							20,000		20,000
Dreisam, g., Cal				51,000	15,000				66,000
Dublin, g., Cal						10,000	5,000		15,000
Dudley, g., Cal.							20,000		260,000
Dutch, g., Cal.				22,500	52,500				75,000
Eagle, g., Oregon.			3,000						3,000
East Honorine, g.s.l., Utah.							5,000	800	5,800
East Sierra Nevada, s., Nev								5,000	25,000
East Valeo, g., Utah						5,000			5,000
Eclipse, g., Cal								5,000	5,000
Eldorado Oil, Cal.							10,000		10,000
Elephant, g.s.l., Utah								5,000	5,000
Ella Eldon, g., S. Dak						500		500	1,500
El Rey, g., Utah.					8,000				8,000
Elsie, g.s.l., Utah.							10,000	10,000	20,000
Ely, g., Utah				2,000	3,000		2,000		7,000
Emerald, g.s., Utah.			3,000			1,500	10,750	6,000	21,250
Empire Oil, Cal						14,000			14,000
Equality Oil, Cal							10,000		10,000
Esperanza, g., Cal								5,000	5,000
Eureka Con., s., Nev			10,000	5,000					519,000
Eureka Con. Drift, g., Cal.		75,000	5,000	15,000	17,500	10,000	5,000	7,500	235,500

ASSESSMENTS LEVIED BY MINING COMPANIES.—*Continued.*

Name of Company.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	Total Levied.
Eureka-Swansea Ext., g.s., Utah					$5,000				$5,000
Eutonia, s.l.g., Utah					9,000	$2,000	$6,000	$2,000	19,000
Excelsior Drift, g.s., Cal			$667	$5,000	2,000				7,677
Exchange, g.s., Utah					1,000	1,500			2,500
Exchequer, s., Nev	$5,000	$5,000			3,000			8,000	1,031,000
Fall Creek, g., Cal						10,000			10,000
Fall River, g.s., Cal				2,500					2,500
Fauna Oil, Cal.								1,500	1,500
Fifteen-Three Oil, Cal.							10,000		10,000
Fish Springs, g., Utah					1,500				1,500
Florence, g.s., Utah				1,000					1,000
Forlorn Hope, g., Cal			20,000						20,000
Four Aces, g.s., Utah		2,500	2,500	2,500	17,500	5,000			27,500
Free Coinage, g., Utah						5,000			5,000
Free Silver, s.l., Utah								500	500
Fremont, g.s., Utah					2,500				2,500
Fremont Con., g., Cal.							10,000	15,000	25,000
Fresno & S. Benito Oil, Cal.							4,000		4,000
Frisco, g.s., Utah				2,000	2,000				32,000
Fullerton & Sunset Oil, Cal						3,000			3,000
Galata, g., Cal			10,000						10,000
Galena, g., Utah			10,000			5,000	6,000	5,000	26,000
Galena Treasure, g.s., S. Dak.				200	200				400
Gambetta, g., Cal								9,000	9,000
Garden City, g.s., S. Dak					563				7,105
Garibaldi, g.s., Cal.				4,000	4,000		3,000		11,000
Genevieve, g.s., Utah				5,000					5,000
Gerrymander, g.s., Cal				10,000	5,000		5,000		20,000
Geyser, s.l., Colo			50,000	200,000					1,275,000
Geyser-Marion, g.s., Utah					9,000				9,000
Giant Oil, Cal.						24,107			24,107
Gibraltar Con., g., Cal.						5,000			5,000
Golconda, g.s., Nev						750		750	2,250
Gold Coin (Gilpin Co.), Colo.				10,000					10,000
Golden Channel, g., Cal.				3,000	2,500			1,500	7,000
Golden Eagle, g.s., Nev.				4,000			1,320	1,320	6,640
Golden Fleece, g., Cal								25,000	25,000
Golden Gate Ext., Utah								2,000	2,000
Golden Jubilee, g., Cal							5,000	5,000	10,000
Golden King, g., Cal			3,500						3,500
Golden Star, g.s., Cal.				2,000	1,500	2,500	4,000		10,000
Gold Hill, g.s., Cal					25,000	25,000	25,000	12,000	87,000
Gold Hill, g.s., Utah					1,000	500	500		2,000
Gold Leaf, g.s., Wash				100					100
Gold Run Dev., g., Cal								10,000	10,000
Gold & Silver Carb., g.s., Utah.				2,500					2,500
Goleta, Con., g., C					63,000	30,000			93,000
Gonyon, g.s., Utah					2,500	3,750			6,250
Good Hope, g., Utah						2,000			2,000
Good Title, g., Cal.			20,000						20,000
Gould Central Oil, Cal.						5,000			5,000
Gould Oil, Cal						25,000			25,000
Gould & Curry, s., Nev.	48,600	59,400	37,800	49,400	54,800	43,200	32,400	37,800	4,856,650
Grand Prize Oil, Cal						20,000			20,000
Granite Hill, g.s., Cal.				3,000					3,000
Grape Vine Canyon, g.s., Cal				10,000	14,000	10,000		5,000	39,000
Great Bonanza, g.s., Utah					5,000				5,000
Great Eastern, g.s., Utah			1,500	1,500	1,500				4,500
Great Western, q., Cal.			5,000	20,000					75,520
Grizzly, g.s., Cal.			1,500		5,000		10,000	30,000	46,500
Gypsy Blair, g.s.l., Utah.								10,000	10,000
Hale & Norcross, s., Nev.				39,200	22,400	11,200	44,800	44,800	5,840,680
Hanford-Fresno Oil, Cal.						24,140			24,140
Hanford-Sanger Oil, Cal.						6,000			6,000
Hawk-McHenry, g.s.l., Utah.							15,000		15,000
Head Center Con., g.s.c., Ariz				25,125					25,125
Hercules, g.s., Utah.					20,000				20,000
Hester A., g.s., S. Dak.					500				3,000
Highland, g.s., Utah.					8,000				8,000
Highland (Leadville), g.s., Colo.					125,000				125,000
Hilda Gravel, g.s., Cal.			2,000		2,000				4,000
Hillside, g.s., Utah				1,500					1,500
Himalaya, g.s., Utah.				5,000					5,000
Home, g.s., Cal.			3,000		10,000				13,000
Homestake, g.s., Utah			4,000	4,000			10,000		60,000
Horn Silver Tunnel, g.s., Utah.				500	500				1,000
Horsefly, g., Cal.			8,000			10,000			18,000
Horseshoe Bar Con., g.s., Cal			6,000	3,000	1,200	600			87,600
Humboldt, g.s., Cal.				2,000					2,000
Imperial, Cal						2,000	3,000		5,000
Independence, g.s., Utah				6,000	9,000		5,000		15,000
Independent, g., Cal.						10,000		15,000	25,000
Indian Pete, g.s.l., Utah								5,000	5,000
Ingot, g.s.l., Utah						10,000			10,000
International, g.s., Utah.				1,500		5,000			6,500

ASSESSMENTS LEVIED BY MINING COMPANIES.—*Continued.*

Name of Company.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	Total Levied.
Inyo Marble, Cal	......	......	......	......	......	$5,000	$5,000	$6,000	$181,000
Iron Prince, g. s. l., Utah	......	......	......	......	......	......	......	625	625
Jefferson, g. c., Utah	......	......	......	......	$1,500	1,750	......	......	3,250
Jennie Lind, g. s., Cal	......	......	......	$2,000	2,000	8,000	9,000	6,000	27,000
Joe Bowers, g. s., Utah	......	......	......	......	14,000	21,000	10,500	10,500	56,000
Joe Bowers Ext., g. s., Utah	......	......	......	......	15,000	......	......	......	40,500
Jubilee, g., Cal	......	......	......	......	......	......	10,000	25,000	35,000
Julia Con., s., Nev	$5,500	$5,500	......	3,300	3,300	......	6,600	3,300	1,511,700
Jumbo, g. s., Utah	......	......	$500	......	......	......	1,200	800	2,500
Junction, g. s., Cal	......	......	10,500	6,000	......	......	......	......	16,500
Junction Oil, Cal	......	......	......	......	......	25,000	......	......	25,000
Jupiter Gravel, g., Cal	......	40,000	40,000	......	......	......	......	......	80,000
Justice, s., Nev	......	......	10,500	21,000	15,750	21,000	17,750	31,500	3,753,750
Karan, g., Cal	......	......	2,500	......	......	......	......	......	2,500
Karma, g., Cal	......	......	......	......	......	......	......	5,000	5,000
Karl Brown Oil, Cal	......	......	......	......	......	15,000	......	......	15,000
Kate Hayes, g. s., Cal	......	......	10,000	10,000	......	......	......	......	70,000
Kennedy, g., Cal	......	......	......	......	......	......	......	10,000	10,000
Kentuck, g., Utah	......	......	30,000	......	......	......	......	......	30,000
Kentuck Con., s., Nev	5,250	10,500	5,250	......	3,150	......	......	8,400	136,850
Kern Canyon Oil, Cal	......	......	......	......	......	......	......	6,000	6,000
Kern River Oil, Cal	......	......	......	......	......	40,000	20,000	20,000	80,000
Kern Sunset Oil, Cal	......	......	......	......	......	2,000	......	......	2,000
Keystone, g., Cal	......	......	......	......	......	......	3,000	......	3,000
Kings County Oil, Cal	......	......	......	......	......	6,000	......	......	6,000
Lady Washington, s., Nev	5,400	......	......	5,400	......	......	8,640	5,400	180,480
La Grange, g. s., Cal	......	......	......	15,000	......	......	......	......	15,000
Laird, g., Cal	......	......	10,000	......	......	......	......	......	10,000
La Palma, s. l., Mex	......	......	......	......	......	......	......	30,000	30,000
La Reine, g. s. l., Utah	......	......	......	......	......	......	5,000	3,000	8,000
Larkin, g. s., Cal	......	......	2,000	2,000	4,000	10,000	12,000	5,000	45,000
La Suerte, g. s., Cal	......	......	7,500	7,500	7,500	5,000	4,750	7,500	59,750
Laurel, g., Cal	......	......	......	......	......	......	2,500	......	2,500
Leo, g., Mont	......	......	......	......	......	2,500	......	......	2,500
Leon, g., Cal	......	......	1,500	......	......	......	......	......	1,500
Linda Vista Oil, Cal	......	......	......	......	......	11,460	3,000	......	14,460
Lion Con., g. s., Utah	......	......	......	500	500	......	......	......	1,000
Little Bell, g., Utah	......	......	......	......	......	37,500	......	......	37,500
Little Chief, g. s., Utah	......	......	......	8,000	12,000	16,000	16,000	12,000	64,000
Little Jimmie, g. s. l., Utah	......	......	......	......	......	......	1,875	......	1,875
Little Pell Con., g. s. l., Utah	......	......	......	......	......	......	......	10,000	10,000
Little Pittsburg, g.s., Utah	6,000	4,000	4,000	5,000	......	......	......	......	23,000
Little Standard Oil, Cal	......	......	......	......	......	......	......	10,000	30,000
Live Oak, Con., g.s., Cal	......	......	20,000	10,000	10,000	......	8,000	......	48,000
Live Yankee, g.s., Cal	......	......	5,000	2,000	......	......	......	......	7,000
Lombard, g.c., Utah	......	......	......	......	......	1,250	......	......	1,250
Los Angeles Oil, Cal	......	......	......	......	......	......	......	5,000	5,000
Louis, S., g., Utah	......	......	......	......	......	10,000	......	......	10,000
Lower Mammoth, g.s., Utah	......	......	12,500	15,000	15,000	......	......	......	42,500
Lucky Bill, g.s., Utah	7,200	6,600	1,800	2,500	2,400	12,000	......	18,000	91,300
Lulah, Con., g.s., Utah	......	......	......	1,500	......	......	......	......	1,500
Madeline, g.s.l., Utah	......	......	......	......	......	......	10,000	......	10,000
Madsen, g., Utah	......	......	......	......	......	1,250	2,500	2,500	6,250
Mammoth, g.s., Nev	......	......	......	......	......	......	2,000	......	2,000
Mammoth Garfield, g.s., Cal	......	......	......	......	17,500	......	......	......	17,500
Manhattan, g., Utah	......	......	......	......	......	2,500	7,500	5,000	15,000
Maple, g.s., Utah	......	......	......	......	......	3,000	6,000	4,000	13,000
Maple Creek, g., Cal	......	......	......	......	......	10,000	......	20,000	30,000
Marguerite, g.s., Cal	......	20,000	15,000	15,000	......	......	......	......	85,000
Marina Mariscano, g.s., Cal	......	16,360	19,000	19,000	7,000	1,000	24,000	18,000	104,360
Mariposa Com'l & M'g., g.s., Cal	......	......	......	......	50,000	50,000	......	......	210,000
Marmaduke, g.s., S. Dak	......	......	......	......	500	......	......	......	500
Martha Washington, g.s., Utah	......	......	3,000	6,000	6,000	9,000	15,000	15,500	54,500
Martin White, s., Nev	......	......	......	120,000	......	......	......	......	120,000
Maxfield, g.s., Utah	......	......	6,000	9,000	9,000	......	......	......	24,000
Mayday, g.s., Cal	......	......	5,000	10,000	5,000	2,500	1,500	1,500	25,500
Mayday, g.s., Utah	......	......	2,000	2,000	......	......	......	22,000	26,000
Mayflower, g.s., Utah	......	......	......	......	2,000	5,000	5,000	2,500	14,500
Mayflower Gravel, g.s., Cal	......	......	6,000	......	7,500	6,000	......	......	19,500
Mazeppa, g.s., Cal	......	......	......	......	5,000	......	2,000	2,000	9,000
McKinley, g., Utah	......	......	......	......	......	......	1,250	......	1,250
McKittrick, Con., Oil, Cal	......	......	......	......	18,000	18,000	......	......	36,000
McKittrick Oil, Cal	......	......	......	......	......	15,000	6,000	......	21,000
Melcher, g.s., Utah	......	......	......	......	1,000	625	1,375	1,500	4,500
Menlo, g., Cal	......	......	......	......	......	......	6,000	......	6,000
Mercantile Crude Oil, Cal	......	......	......	......	......	......	5,000	......	5,000
Merrimac, g., Cal	......	......	20,000	......	......	......	......	......	20,000
Metallic Hill, g.s.l., Utah	......	......	......	......	......	......	......	5,000	5,000
Meteor, g.s., Utah	......	......	3,734	4,999	2,997	1,980	......	......	13,690
Mexican, s., Nev	40,320	20,000	40,320	25,200	45,360	50,400	30,240	40,320	2,480,480
Middle Yuba, g., Cal	......	......	......	......	......	......	......	25,000	25,000
Midland, g.s., Utah	......	......	......	......	3,000	......	......	......	3,000
Midnight Bowers, g.s., Utah	......	......	......	1,000	1,000	......	......	......	2,000
Mineral Hill, g., Cal	......	......	......	......	......	......	......	2,000	6,000
Minnehaha Oil, Cal	......	......	......	......	......	10,000	......	......	10,000

ASSESSMENTS LEVIED BY MINING COMPANIES.—*Continued.*

Name of Company.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	Total Levied.
Minnie, g., Utah								$1,000	$4,000
Mistletoe, g., Cal							$1,000		100,000
Mohave, g.s.l., Utah								5,000	5,000
Mohican, g., Cal						$10,000	5,000		15,000
Molly Bawn, g.s., Utah				$1,000					1,000
Montecito, g., Cal			$10,000						10,000
Monte Cristo, g.s., Utah							2,500		2,500
Montreal, g.s., Utah		$375		25,000					30,625
Mooney Con., g.s., Cal					$20,000				20,000
Morgan, g., Cal			10,000					10,000	20,000
Morning Glory, g., Wash							3,000		3,000
Morning Star, g.s., Nev								500	500
Mountaineer, g.s., Cal			15,000		25,000				40,000
Mountain Lake, g.s.l., Utah							5,000	2,500	7,500
Mountain View, g., Cal						15,000			15,000
Mt. Blanc Con., g., Cal						1,250			1,250
Mt. Diablo Oil, Cal						10,000	5,000		65,000
Mt. Pleasant, Con., g., Cal								15,000	15,000
Murray Hill, g.s.l., Utah								15,000	15,000
Naildriver, g.s.l., Utah								2,500	2,500
Nancy Hanks, g., Cal			5,000						5,000
Napa County, c., Cal								5,000	5,000
Nashville, g., Cal			2,000						2,000
National Con., g.s., Cal			15,000	45,000	15,000	10,000	5,000	5,000	88,685
Navajo, g.s., Utah						2,500			2,500
Nevada County Oil, Cal								3,000	3,000
Nevada, s., Nev					10,000				10,000
Nevada, c., Utah							5,000		5,000
New Almaden, q., L. Cal								5,000	5,000
New Boston, g.s.l., Utah								500	500
New Independence, g., Cal								20,000	20,000
New Century Oil, Cal						15,000			15.000
New Erie, g.s., Utah				2,000	500	7,500	500		10,500
New Imperial, g.s., Utah				1,000					1,000
New Klondike, g.s., Utah				2,961	235				3,196
New La Plata, g.s., S. Dak					300				1,700
New Mercur, g.s., Utah							4,200	2,100	6,300
New Montezuma, g., Cal							10,492	10,531	26,206
New Pass, g.s., Nev								20,000	20,000
New Redwing, g.s.l., Utah							15,000	22,500	37,500
New Southern Cross, g., Mont						5,000			5,000
New State, g.c., Utah					1,500				4,500
New York Bonanza, g.s.l., Utah								18,000	18,000
Niagara M. & S., Utah							97,500		97,500
Nineteen Oil, Cal						6,000			6,000
Nixon Placer, g., Cal								5,000	5,000
North Bloomfield, g., Cal			25,000						25,000
North Bonanza, s., Nev					15,000				255,000
North Gould & Curry, s., Nev	$10,000		20,000						375,000
North Mercur, g., Utah			10,000						10,000
Northern Light, g., Cal								5,000	5,000
Northern Light, g.s., Utah			8,000		8,000	18,000	16,000		50,000
Northern Spy, g.s., Utah			10,000	10,000					20,000
Nugget Placer, g., Cal						10,000			10,000
Occidental Con., s., Nev	65,000	30,000	20,000	20,000	5,000	10,000	15,000	20,000	569,170
Okanogan, g., Wash					10,566				10,566
O. K. Extension, g.s.l., Utah								5,000	5,000
Olcorose, Cal							3,000		3,000
Old Bonanza, g.s., Cal				2,500					2,500
Old Bullion, g.s., Utah							4,000		4,000
Old Colony & Eureka, g.s., Utah					2,500		2,500	8,750	18,750
Old Evergreen, g.s., Utah							6,000	6,000	12,000
Old Home, g.s., Cal			5,000	3,500	3,500	1,000			13,000
Old Home Con., g.s., Cal					3,500	1,000	2,000		15,000
Old Indian, g.s., Utah							2,000		4,000
Old Susan, g.s., Utah					7,500	500			8,000
Olinda Oil, Cal							10,000		10,000
Omaha, g.s., Utah					6,000				6,000
Omaha Con., g.s., Cal			10,000	25,000	100,000		50,000	66,500	251,500
Ophir, s., Nev	25,200	25,200	43,200	50,400	60,480	45,360	45,360	45,360	4,839,528
Ophir (Cent. Dist.), g., Nev							6,000		15,000
Opohonga, g.s., Utah			1,500	1,000					2,500
Orient, g.s., Cal				50,000	75,000	35,000		35,000	195,000
Orient, g., Utah						2,500	2,000		4,500
Orleans, g.s., Cal			15,000	12,000		5,000			32,000
Oro Quartz, g.s., Cal				4,500					4,500
Osceola Con., g.s., Cal			1,000	1,000	2,000	2,000			15,810
Overman, s., Nev	34,560	17,280	17,280	11,520	17,268	23,040	23,040	34,560	4,239,030
Pacific, g.s., Utah				500	750		600		1,850
Paria, c., Utah							2,500		7,500
Park City, g.s.l., Utah								625	625
Patterson Creek, Cal							10,000		10,000
Peabody, g.s., Cal					10,000				10,000
Peruvian Con., g.s.l., Utah								7,500	7,500
Petroleum Center Oil, Cal					20,500	61,500	20,500		102,500

ASSESSMENTS LEVIED BY MINING COMPANIES.—*Continued.*

Name of Company.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	Total Levied.
Petrolia Oil, Cal.						$10,000			$10,000
Phoenix, g.s., Utah		$1,000			$1,000				2.000
Picnic, g.s., Utah					1,000				1,000
Pilot, g., Cal							$10,000		10,000
Pioneer, g.s.l., Utah							1,000		1,000
Planet, g., Cal							10,000	$20,000	30,000
Posey, Con., g., Cal								25,000	25,000
Potosi, s., Nev	$28,000	50,400	$50,400	$39,200	39,200	28,000	22,400	39,200	2,325,200
Powning, g.s., Cal.				2,500			2,500		5,000
Princess Maud, g.s.l., Wash							3,000		3,000
Prior Hill, g.s., S. Dak.					200				1,000
Prospect M't'n Tunnel, Nev							10,000		10,000
Prosperity Oil, Cal.						25,000			25,000
Providence, g., Cal.						20,000			20,000
Provident Oil, Cal.						7,500		7,500	15,000
Purjue Sur., g.s.l., Utah.							1,000		2,000
Queen Esther Oil, Cal.						5,000			5,000
Quincy, g., Cal				10,000	20,000				30,000
Raven Oil, Cal.						10,500			10,500
Raymond, g., Utah						12,500			12,500
Reamer Con., Cal.							10,000	20,000	30,000
Red Bank Oil, Cal.						6,000			6,000
Reddick, g.s., Cal.			5,000	5,000			3,000		13,000
Red Jacket, s., Nev				2,000					2,000
Red Slide, g., Cal								20,000	20,000
Red Wing, g.s.l., Utah							1,000		1,000
Red Wing Ext., g.s.l., Utah.							500		1,000
Rescue Gold, Nev		3,000	2,000	500					5,500
Revenue, g.s., Utah.				4,500					4,500
Reward, g.s., Cal.		7,040	3,840	3,200	9,920	14,500	6,000		97,500
R. G. W., g.s., Utah.				2,000	1,000	2,500	1,500		7,000
Rich Bar Gravel, g.s., Cal.					6,000				6,000
Richmond, g., Cal			10,000						10,000
Ridge & Valley, g.s., Utah					5,000	10,000		12,500	27,500
Roberts Oil, Cal.						3,000			3,000
Rockland, g., Cal.			3,000						3,000
Romeo Con., g.s.l., Utah.								5,000	5,000
Rose Creek, g.s., Cal			5,000	5,000					10,000
Ruby Hill, g.s., Utah.					600	1,000	1,000		2,600
Rusby, g., Cal.							14,000	7,000	21,000
Sacramento, g.s., Utah				600		2,500			3,100
Sailor Con., g.s., Cal.				11,000	6,000	3,000	1,000		21,000
Salmon River, s., New				1,425					11,970
Salt Lake & Nev, g.s., Utah.			1,000			2,500			3,500
Sam Houston, g.s., Cal							10,000	5,000	15,000
Sampson, g.s.l., Utah.							10,000	5,000	15,000
San Pablo Oil, Cal.							5,000		5,000
Santa Rosalia, q., Mex					5,000				5,000
Savage, s., Nev	67,200	67,200	44,800	22,400	33,600	22,400	33,600	33,600	7,433,200
Scorpion, s., Nev.		5,000			3,000			5,000	453,000
Sea Breeze Oil, Cal.						20,000			20,000
Sea Swan, g., Utah						2,500			2,500
Seg. Belch. & Mides, s., Nev	10,000	10,000	8,000	10,000	6,000	6,000	3,000	20,000	413,000
Sharp, g., Utah						5,000			5,000
Shasta County Sm. & Ref., Cal								25,000	25,000
Shasta Oil Cal						20,000			20,000
Sheba, g.s., Cal.					10,000				10,000
Sheep Ranch, g., Cal								115,000	115,000
Sheep Rock, g.s., Utah.		5,250			52,500				57,750
Shenandoah Con., g., Cal						4,000		8,000	12,000
Shoebridge-Bonanza, g.s., Utah					3,200	4,000			13,600
Showers Con., g.s., Utah				8,000	2,000	24,000	12,000		46,000
Sierra, g., Cal.								10,000	10,000
Sierra Nevada, s., Nev	50,000	40,000	20,000	50,000	45,000	50,000	30,000	40,000	6,921,910
Sierra Union W'r & Mg., Cal.							75,000		75,000
Silver Bell, s., Utah.			5,000					5,000	20,000
Silver Bow, g.s., Utah.					5,000	7,500	5,000		17,500
Silver Cloud, g.s., Utah.				5,000		2,500			7,500
Silver Coin, g.s.l., Utah.								5,000	5,000
Silver King, g.s., Ariz	75,000	50,000	50,000	50,000	25,000	25,000	15,000		530,000
Silver Park, g.s., Utah.					9,000				9,000
Silver Queen, g.s., Utah.					1,000			2,500	3,500
Silver Shield, g., Utah.						3,000	6,000	33,000	42,000
Silver State, g.s., Utah		1,000			500		2,500		4,000
Siskiyou Con., g.s., Cal.	2,000		3,000	3,000	6,000				55,000
Skagit Cumb., Coal, Wash					7,500	22,500			29,500
Skylark, c., Utah.						5,000	7,500	5,000	27,500
Snake Creek Con., g.s.l., Utah.								2,500	2,500
Snow Flake, g.s., Utah			2,000	5,000	2,000	7,000	10,000	15,000	54,500
Snowstorm, g.s., Utah.						2,500			2,500
Sonora, g., Cal					5,000	4,000	8,000	2,500	19,500
Sonora Quartz, g.s., Mex					5,000		10,000		5,000
South Bingham, g.s., Utah.				2,500	2,500				5,000
South Eureka, g.s., Cal				6,000			3,000	8,000	17,000
South Fork Con., g.s., Utah.			5,000						5,000

ASSESSMENTS LEVIED BY MINING COMPANIES.—*Concluded.*

Name of Company.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	Total Levied.
So. Queen, g.s.l., Utah							$1,250		$1,250
South Lily, g.s.l., Utah							500		2,000
South Paloma, g.s.. Cal.					$1,200				1,200
South Sliger, g., Cal.						$10,000		$3,000	13,000
South Swansea, g.s.l., Utah								24,000	24,000
Spanish Bar, g.s., Cal			$2,000	$5,000	11,000	5,000			23,000
Spence Mineral, Cal.							6,000		6,000
Spider, g.s.l., Utah								2,000	2,000
Springfield, g.s.l., Utah.							5,000		5,000
Stansbury, g.s.l., Utah								2,500	2,500
Star, g.s., Utah			5,000	30,000	25,000		7,500	5,000	72,500
Steamboat, g.s.l., Utah.								750	750
St. Louis-Vassar, g.s.l, Utah								10,000	10,000
Stockton, g.s.l., Utah							5,000	1,000	6,000
Success, g.s., Utah.				9,750	3,000				12,750
Sumdum, g., Alaska							25,000	25,000	50,000
Sumdum Chief, g., Alaska							25,000		25,000
Sunbeam Con., g.s., Utah.		$11,250	5,000	50,000	55,000				131,383
Sunrise, g.s.l., Utah.							750	1,000	1,750
Sunset District Oil, Cal.						7,500			7,500
Superior Oil, Cal						4,600			4,600
Swansea, g.s.l., Utah.								15,000	18,500
Sweet Vengeance, g.s., Cal.					10,000				130,000
Tanama, g.s., Cal.				10,000		30,000	10,000	10,000	60,000
Tesora, g.s., Utah					2,750	80,000			102,000
Tetro, g.s., Utah			18,000	15,000	15,000	27,000	12,000	12,000	102,500
Texas, g.s., Cal.				15,000	30,000	10,000			55,000
Thorpe, g.s., Cal.			5,000	5,000					10,000
Tintic, g.s., Utah				4,375					4,375
Tintic Copper King, Utah.							2,500		2,500
Tomboy, g., Utah					5,000		2,500		7,500
Tonopah, Salt Lake, Nev								20,000	20,000
Tracy, g.s., Cal.				5,000					5,000
Trent, g., So. Dak						1,500			7,500
Troy, g.s., Alaska		2,000	6,250	6,250					16,750
Tule Belle, g., Cal						10,000		10,000	20,000
Tuscarora Chief, g.s., Utah.				2,000					2,000
Twentieth Century, g.s.l., Utah							1,250		2,500
Ukiah Oil, Cal						10,000			10,000
Ultimo, g., Cal.							30,000	21,000	51,000
Uncle Sam, g.s.l., Utah.							6,000		6,000
Union Con., s., Nev.	$40,000	20,000	30,000	18,000	30,000	25,000	30,000	30,000	2,775,000
United Sunbeam, g., Utah.						30,000	20,000		50,000
U. S. Grant, g.s., S. Dak.					1,000				4,500
Usona Oil, Cal.							1,000		1,000
Utah Con., s., Nev.	10,000	30,000	20,000	15,000	15,000	20,000	20,000	10,000	550,000
Utah Wyoming Oil, Utah.							2,500	2,500	5,000
Uyak Bay, g., Alaska							3,000		3,000
Valeo, g.s., Utah.				10,000	10,000				20,000
Vallejo, q., Cal			2,000	2,000					4,000
Valley View Oil, Cal						17,500			17,500
Vernon Oil, Cal						25,000			25,000
Victor, g.s., Utah.	375				15,000	5,000	15,000		35,375
Victoria, g.s., Utah					4,000				4,000
Victory, g.s., S. Dak					200				2,825
Virginia Con., g., Cal.							10,000		120,000
Vulcan Sm. & Ref., Cal.							5,000	10,000	15,000
Wandering Jew, g.s.l., Utah.							500		3,500
Wasatch, Utah						6,000			6,000
Washington Con., g.s., Wash					200				2,000
Washington Oil, Cal.						7,000			7,000
Watt Blue Gravel, g.s., Cal.				3,000					58,000
Wedge Exten., g.s.l., Utah.							500		500
Wellington Oil, Cal						7,000	7,500	5,000	19,500
West Argent, Utah						10,000			10,000
West Century, g.s.l., Utah							5,000	5,000	10,000
Western Union Oil, Cal.							1,000		3,000
West Lake Oil, Cal						10,000			10,000
West Morn'g Glory, g.s., Utah.					1,250	1,250	13,750		21,000
West M't'n Placer, g.s., Utah.					8,000	3,750			11,750
White Pine, g.s., Nev								5,000	5,000
William Tell, g., Cal								1,500	1,500
Willietta, g., Cal						10,000	20,000	30,000	60,000
Wilson & Barrett, g.s.l., Utah							30,000		30 000
Wisconsin Oil, Cal						25,000			25,000
Yankee Con., g.s., Utah				2,500	5,000	10,000			17,500
Yankee Girl, g.s., Utah.				5,000					5,000
Ybarra, g., Cal							10,000	20,000	30,000
Yellow Jacket, s., Nev.	90,000		24,000	36,000	42,000	36,000	36,000	30,000	5,970,000
Young America, g.s., Utah.					8,000				8,000
Yuba Con., g., Cal.			2,500			45,000	6,000		53,500
Zacca Lake Oil, Cal						1,875			1,875
Zuba, g., Cal.			5,000						5,000

c., copper; g., gold; i., iron; l., lead; q., quicksilver; s. silver; z., zinc.

INDEX.

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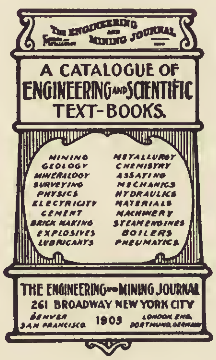
Alphabetical Index.



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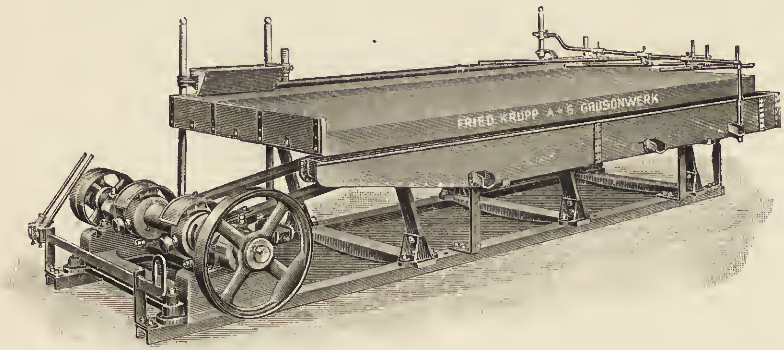

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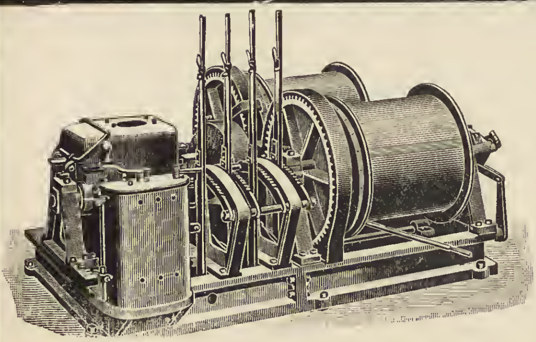

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Index.

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